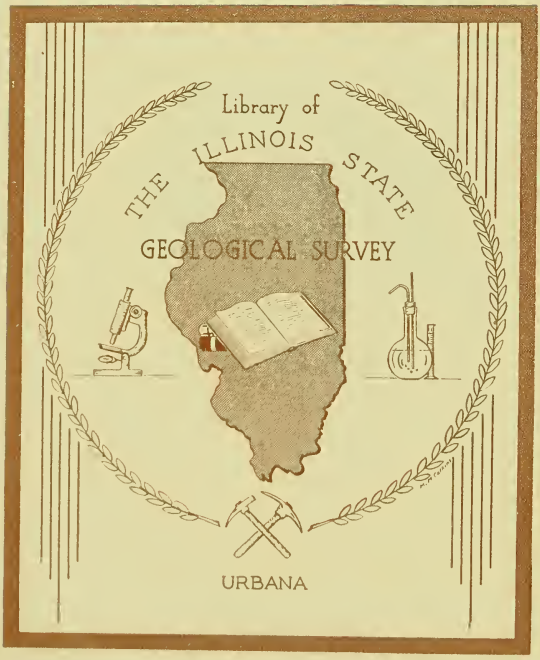

Library of
THE ILLINOIS STATE
GEOLOGICAL SURVEY
URBANA

57
.6c
.196
.1

STATE OF ILLINOIS
WILLIAM G. STRATTON, *Governor*
DEPARTMENT OF REGISTRATION AND EDUCATION
VERA M. BINKS, *Director*

DIVISION OF THE
STATE GEOLOGICAL SURVEY
JOHN C. FRYE, *Chief*
URBANA

CIRCULAR 196

MINERAL RESOURCE RESEARCH AND ACTIVITIES OF THE STATE GEOLOGICAL SURVEY, 1953-1954

BY

M. M. LEIGHTON, *Chief, Emeritus*

Preprinted from the Annual Report of the Chief to the Director,
Department of Registration and Education,
for Fiscal Year 1953-1954

PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

URBANA, ILLINOIS
1955

ILLINOIS GEOLOGICAL
SURVEY LIBRARY
JUN 6 1955

Figure 1.—The Natural Resources Building, on the University of Illinois campus, was constructed to house the offices and laboratories of the Geological Survey and the Natural History Survey, divisions of the Department of Registration and Education. The central unit was built in 1940; wings added to the east and west were occupied in 1950.

Dr. M. M. Leighton

MINERAL RESOURCE RESEARCH AND ACTIVITIES

of the

STATE GEOLOGICAL SURVEY, 1953-1954

by

M. M. Leighton, Chief

Annual Report of the Chief to the Director, Department of Registration and Education, for the Fiscal Year, 1953-1954

The foundations of Illinois' prestige as a progressive industrialized state lie deep. The expression, so often used in referring to architectural foundations, that they "go clear to bedrock" applies here in a very literal sense. The basic foundation of our State's present economic development is bedrock itself, vast layers of it—limestone and dolomite, sandstone, coal, shales, and clays. Many of these strata, laid down in ancient seas of the remote geologic past, have high intrinsic value and are mined, dug, or quarried for a wide variety of uses. The great value of others lies in the rich mineral deposits they contain, such as oil and gas, lead and zinc, and fluorspar.

That master architect, Nature, built well and for all time. Long after the foundations were laid and had settled, she brought in a contractor from the north in the form of a great ice sheet which, in the course of four successive visits, spread a blanket of loose unconsolidated material over most of the State. On this covering, rich soils have developed to nourish bumper crops. In its porous pockets fresh life-giving rainwaters gathered. The last retreat of the ice sheet left the major rivers and the Great Lakes as we know them today.

Thus was Illinois built with mineral wealth, rich soils, gentle topography, navigable waterways. Nature had indeed built well. It remained for man to discover and develop these wonderful resources. The Indian lived among them for centuries, unaware. The white man turned them to his purpose, and on Nature's fine foundation he has erected the social and economic structure which we call modern civilization.

The value of minerals produced in Illinois in 1953 is shown in the following table:

Coal	$180,647,000
Oil and gas	184,091,000
Clay and clay products	47,444,000
Limestone and dolomite	27,300,000
Cement	23,750,000
Fluorspar	9,050,000
Special sand	5,887,000
Sand and gravel	11,275,000
Zinc, lead, and silver	4,061,000
Lime	6,305,000
Ground silica, tripoli, and ganister	2,816,000
	$502,626,000

In addition, the value of minerals processed in Illinois, though for the most part mined elsewhere, amounted to $397,780,000. These include pig iron, coke and its by-products, slab zinc, and others. Of significance also is the fact that minerals and mineral products accounted for about 50 percent of the revenue freight originating in Illinois in 1953. Thus the combined value of minerals produced and processed in Illinois in 1953 totaled approximately 900 million dollars. No other state in the Upper Mississippi Valley has such a mineral production.

Organization and Duties

Geological investigations sponsored by State government were first undertaken in Illinois as early as 1851, but they were of necessity limited and, except for publications, were terminated in 1875. It was not until 1905, spurred by the rapid growth of industry and the consequent increased need for information on natural resources, that the State Geological Survey was re-established. It has been vigorously and productively functioning without interruption since that date.

The Survey is a research institution charged with the responsibility of establishing information regarding the geological resources of the State and assisting in their development by reporting on the information it secures. Research is carried on both in the field and in the laboratory, and close relationships are maintained with industry in order to keep in touch with its needs and with modern technological develop-

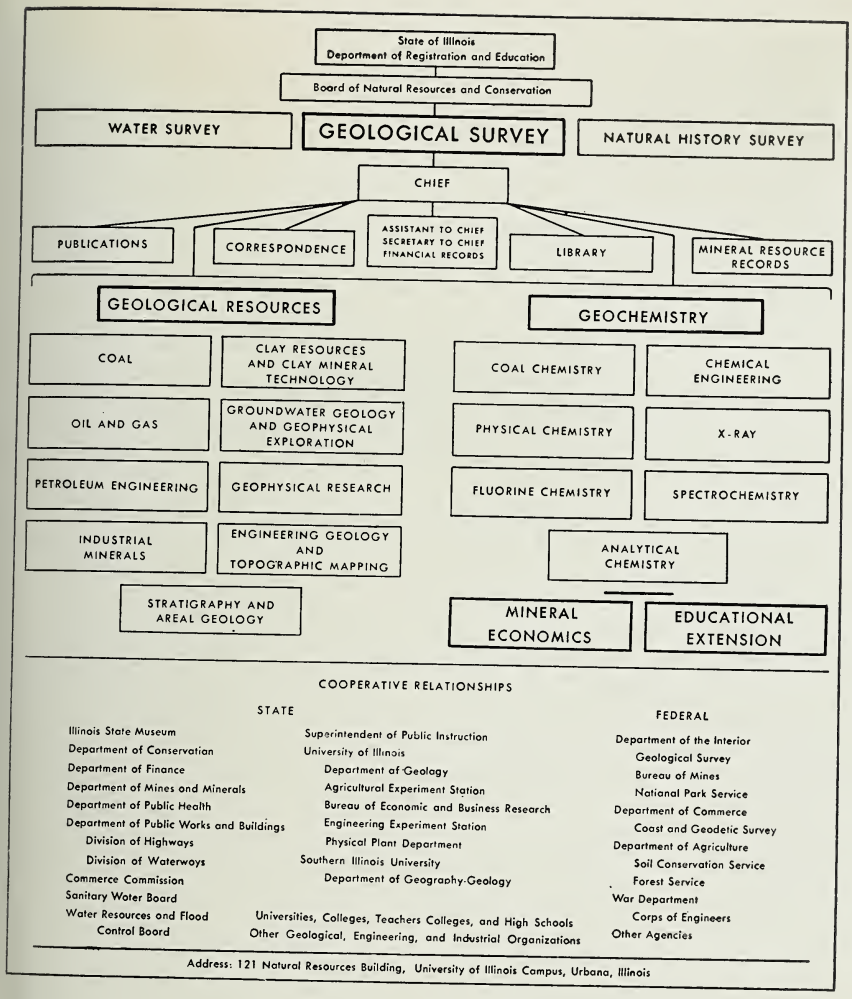


Figure 2.

Organization chart.

ments. Through letters, personal conferences, and its many publications, the Survey seeks to provide accurate information on the State's known and potential mineral resources to landowners, producers, manufacturers, consumers, and interested citizens.

The accompanying chart (Fig. 2) shows diagrammatically the internal organization of the Survey, which is designed to co-ordinate research in varied but closely related fields so that results may be well rounded and comprehensive. In 1953, its scientific and technical staff included 49 geologists, 21 chemists, five engineers, a mineral economist,

two physicists, two editors, a librarian, a photographer, and more than 35 specially trained research and technical assistants.

The Survey's offices and research laboratories and those of the Natural History Survey are housed in the Natural Resources Building (Fig. 1), which was designed especially for the Surveys and was erected on the University of Illinois campus in Urbana in 1940 and enlarged in 1950. In addition to administrative and research offices, there are some 40 laboratories equipped with the most modern scientific apparatus for geological, chemical, and physical research, including X-ray spectrography. A separate building (Fig. 3) provides facilities for large-scale experimental work.

Financial Statement

The amount appropriated to the State Geological Survey for the biennium beginning July 1, 1953 and ending June 30, 1955 was as follows:

Personal Services:	
Regular Positions	$1,324,200
Extra Help	21,000
Contractual Services:	
Postage	6,800
Other	34,900
Travel	32,200
Commodities	63,300
Stationery, Printing, and Office Supplies	55,000
Equipment	30,000
Topographic Surveys	56,500
Employer Contributions to University Retirement System	34,600
	$1,658,500

The actual expenditures and estimated expenditures on contracts through the year ending June 30, 1954 were distributed among the following activities:

Coal (Geology and Chemistry)	$133,180
Oil and Gas and Petroleum Engineering	54,011
Industrial Minerals (Geology and Chemistry)	69,613
Clay Resources and Clay Mineral Technology	19,048
Fluorine Chemistry	14,377
Groundwater Geology and Geophysical Exploration	49,545
Engineering Geology	13,722
Stratigraphy and Areal Geology	69,085
Analytical Chemistry	62,372

X-ray	9,000
Mineral Economics	17,464
Topographic Mapping	28,250
Educational Extension	8,424
Mineral Resource Records	25,464
Library	11,222
Publications (including Printing)	34,567
Other Technical Services, including Photography and Equipment Design	20,088
Clerical Services	26,978
Automotive Services	12,563
General Administration, including Chief's Office, Financial Records, Technical Records, General Information Office, Technical Supplies, Postage, and some Contractual Services	87,961
University Retirement System of Illinois	17,300
	$784,234

RESEARCH ACTIVITIES

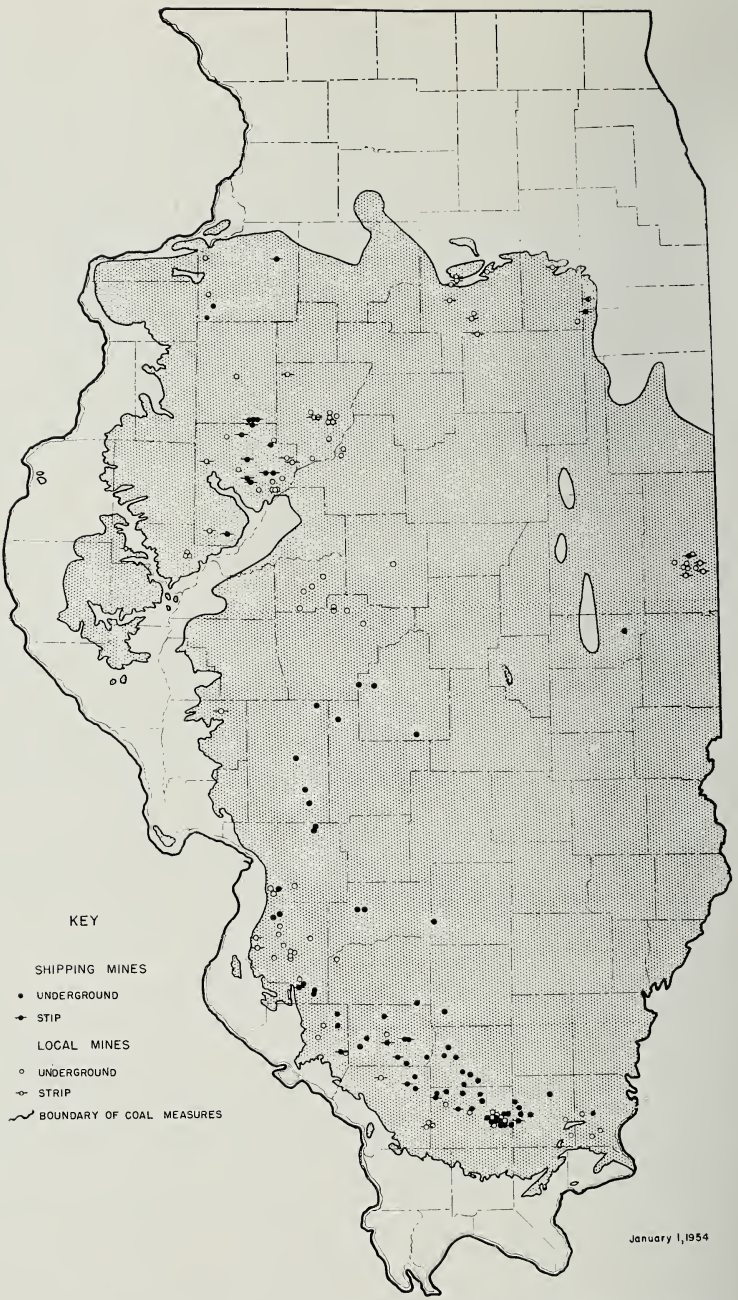
Coal

Illinois produced 45,966,000 tons of coal in 1953, valued at $180,647,000. These figures represent a slight increase over 1952 production. The increase is particularly significant because coal is the State's most valuable single mineral resource and because coal production in the United States has declined steadily since 1951 owing to the increasing use of diesel fuel on our railroads and natural gas for domestic heating.

Despite depressed market conditions in the industry as a whole, interest remained high in deposits from which coal could be shipped by water transport. The recent establishment and expansion of power plant facilities along the Ohio and Tennessee rivers is opening a tremendous new market for Illinois coal, and exploration has been active, particularly in Gallatin County, for the development of new mining operations. In addition, new mines have been opened in Christian, Saline, Williamson, Randolph, and Franklin counties. Although the actual number of shipping mines in Illinois has decreased during the past year, production from new mines and improved mining methods have more than offset the loss resulting from the closing of mines which have reached their economic limit.

The activities of the Survey have been far-reaching and its cooperation with industry has been very active.

1. *Vigorous exploration for new deposits* of coal which will compete in the open market is carried on by the coal industry, and is effectively assisted by the State Geological Survey. Its files contain the most complete assemblage of data anywhere available, and members of its



More than half of Illinois is underlain by the Coal Measures. Dots show locations of shipping mines as of January 1, 1954.

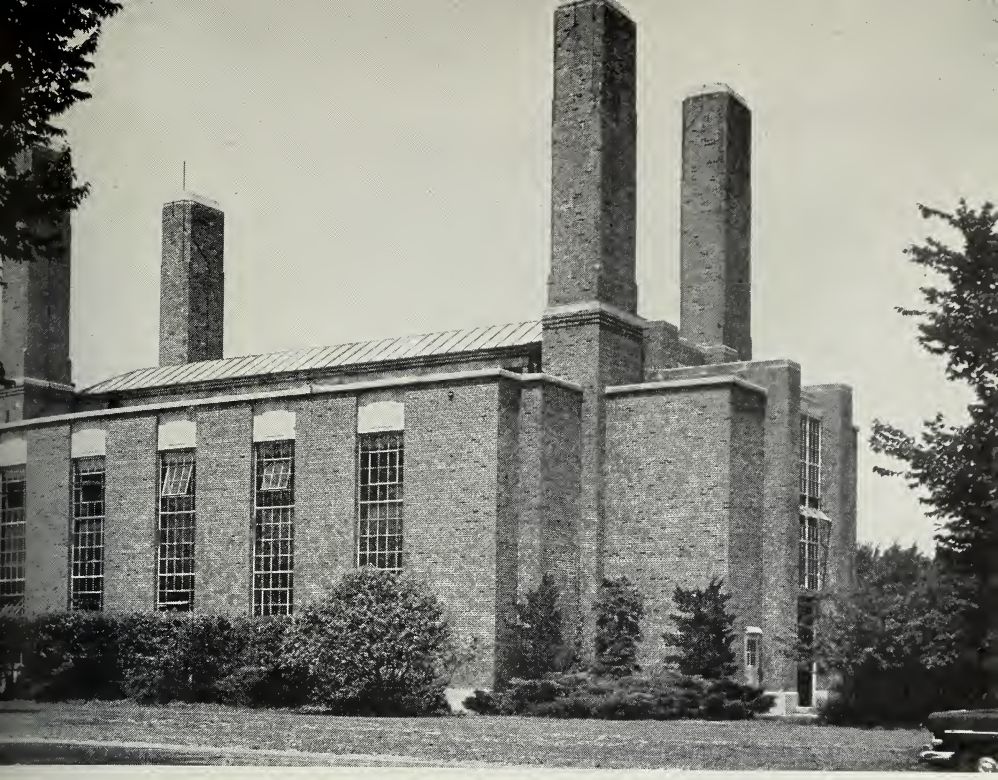


Figure 3.

The Geological Survey's Applied Research Laboratory where semiplant-scale experiments work toward improved products from Illinois coal resources.

staff aid in the search for coal by analyzing drill records, evaluating areas for prospecting, interpreting diamond drill tests made by the coal companies, and contributing information on rank and quality of coals, county by county. Survey geologists are continually engaged in the determination of position, extent, character, availability, and quantity of our coal resources. A series of new structure maps for Wayne County has been completed during the past year based on a large amount of drilling which has been done since the publication of a report on this area some years ago. Similar maps and tabulations of drilling data for Wabash, Jasper, and Vermilion counties have also been prepared, and release is scheduled for the fall of 1954. A special study is in progress on Lawrence County, for which no detailed reports of coal-bearing strata have previously been prepared, and data have been assembled for the preparation of structure maps and cross sections. In response to the greatly increased interest of mining companies in the faults of the Cottage Grove-Shawneetown area in Gallatin and Saline counties, a map is being prepared after careful field studies. A restudy of the areas in the State which contain deposits of strippable coal has been undertaken in order to revise previous publications issued by the

Survey on coal stripping possibilities. First to receive attention are the southeastern counties, Gallatin, Saline, Williamson, Johnson, Pope, and Hardin. Logging of 82 deep coal core tests, made by coal companies in Gallatin County, was completed by the Survey, and approximately ten thousand feet of diamond drill core from Christian, Clark, Crawford, Cumberland, Franklin, Gallatin, Jefferson, Johnson, Saline, Washington, and Williamson counties were logged. Such studies increase available information on coal resources and assist industry to develop them.

2. A *comprehensive report on the minable coal reserves of Illinois* was issued during the year, accompanied by maps showing the coal resources of the State classified as proved, probable, strongly indicated, and weakly indicated. This report brings together for the first time in clearly tabulated form a vast amount of statistical information and is an exceedingly valuable contribution to the general knowledge of the State's coal resources as of 1950. In connection with the preparation of this report maps were drawn showing the mined-out areas on a scale of one inch to the mile. These maps are available separately for the cost of blueprinting.

3. *Greater safety and better coal mine practice* will result from improved roof control. Approximately 50 percent of all coal mine fatalities are due to falls of roof rock and coal. The Geological Survey has been carrying on special investigations to determine the geologic conditions influencing the strength or weakness of coal mine roof materials, especially shale. Work during the past year has consisted primarily of laboratory testing of roof samples collected from more than seventy coal mines working the No. 6 seam in the mining districts of central and southern Illinois. These laboratory investigations include extensive tests of water absorption of mine roof materials, as well as analyses by differential thermal and X-ray techniques. A detailed study was completed of the slaking character, grain size, sorption properties, and mineral constitution of various roof materials and of diamond drill cores from Montgomery, Macoupin, and Sangamon counties. Observation of roof conditions in underground mines continues, and mining companies submit samples of roof materials for evaluation of the geology of roof conditions.

4. *Use of Illinois coal in metallurgical coke manufacture* has become a reality as a result of experimental work undertaken by the Geological Survey in 1943, as a War Production Board project, to determine how Illinois coals could be blended with the more strongly coking Eastern coals currently in use and thus reduce the rail haulage from Eastern coal fields and liberate rolling stock for other critical use. Prior to 1943, no Illinois coal had been used effectively in metallurgical

Coal preparation plant of the Fairview-Collins Corporation's Harmattan mine at Danville.

coke manufacture. In 1944, as a result of the Survey's findings, the use of Illinois coal began and since that time nearly 4,500,000 tons have been used in the coke industry. This coal (from the No. 5 and No. 6 seams) had a value at the mine of about $19,000,000. Its production has given additional employment. Freight charges of over $8,000,000 have been paid to Illinois railroads for haulage from mines to industrial coke plants. This represents a saving to the coke industry in freight alone of $9,000,000 over what it would have cost to transport an equal tonnage of Eastern coal to these plants.

The experimental coke oven designed and constructed in 1943 by members of the Survey staff has operated over a ten-year period with only one major repair. A fund of information has been faithfully recorded from the nearly six hundred experimental blends coked. Plans of this oven design have been furnished to many industrial and governmental research laboratories, and at least ten ovens of this type, now known as "The Illinois Oven," have been built, including one in Chile and one in South Africa. During the past year another experimental

oven has been placed in operation which is designed to measure and record the pressure exerted on oven walls by the expansive force which develops during coking. Operation of this movable-wall oven at rates of heating comparable to those of commercial oven operation has produced coke very similar in physical properties to commercial coke. Thus, complete data on pressure and coke quality are obtained in one operation.

The Survey's new movable-wall coking oven for testing pressures developed during the carbonization of coal.

During the year, over fifty coking runs have been made in the experimental oven and results to date indicate that wherever Illinois coal has been substituted for a portion of the Eastern high-volatile coal, a reduction in pressure has resulted. This property of Illinois coal may make possible its increased use and so further expand the potential market for Illinois coal.

5. *Experimental use of char from Illinois coals* as a possible substitute for Eastern low-volatile coals in metallurgical coking blends has been the object of investigations carried on concurrently with the coking studies just described. Nearly two hundred batches of char were produced in a pilot plant designed and built for the purpose. Illinois coals from the Nos. 2, 5, and 6 seams have been charred and the No. 6 has proved the most satisfactory. Because char possesses no plastic properties, it cannot be coked satisfactorily except when blended with strongly coking Eastern coals or with mixtures of Illinois and Eastern coals, but the Survey's experiments to date indicate that when so mixed, coke of metallurgical quality can be produced without the use of Pocahontas or other low-volatile coals. It appears that the high-volatile coal with which the char is blended has much greater effect on the coke produced than does either the origin of the char or its volatile matter content within the limits of 15 to 24 percent. The establishment of this allowable range of char volatile matter and the discovery that char volatile matter need not be uniform constitute important contradictions of previously held industrial opinions and should appreciably liberalize operating conditions.

6. *High-quality free-burning coal for domestic stokers* is still in large demand. Research to improve stoker fuel has been in progress in the Survey's applied research laboratory for many years and reports have been published showing the relationships between combustion characteristics of coal and its chemical and physical composition as well as the effect of coal size on combustion characteristics. The search by mining companies for premium domestic stoker coal continues, and the Survey makes additional tests as new mining areas are developed. The information obtained from the tests is of value in selecting the coals which should be marketed as premium domestic stoker coals.

7. *The fundamental physical and chemical nature of coal* is still largely a mystery. Basic research has been in progress at the Survey for many years and much light has been thrown on this extremely complex problem. Studies in progress are concerned with the chemical nature of the carbonaceous portion of coal, with particular reference to the changes undergone in weathering; the plastic and swelling properties of coal; the behavior of coal in response to rising temperature in a neutral atmosphere; the submicroscopic structure of coal; X-ray examination of bituminous matter; reflectivity of coal and its relation

to rank; coal petrography to investigate the percentage of banded ingredients in prepared sizes; and improved methods of analyzing and testing coal and coke. Knowledge gained from such studies can only result in eventual improvements in coal preparation and utilization and even in the development of currently unrecognized potential uses for coal and coal derivatives in the chemical industry.

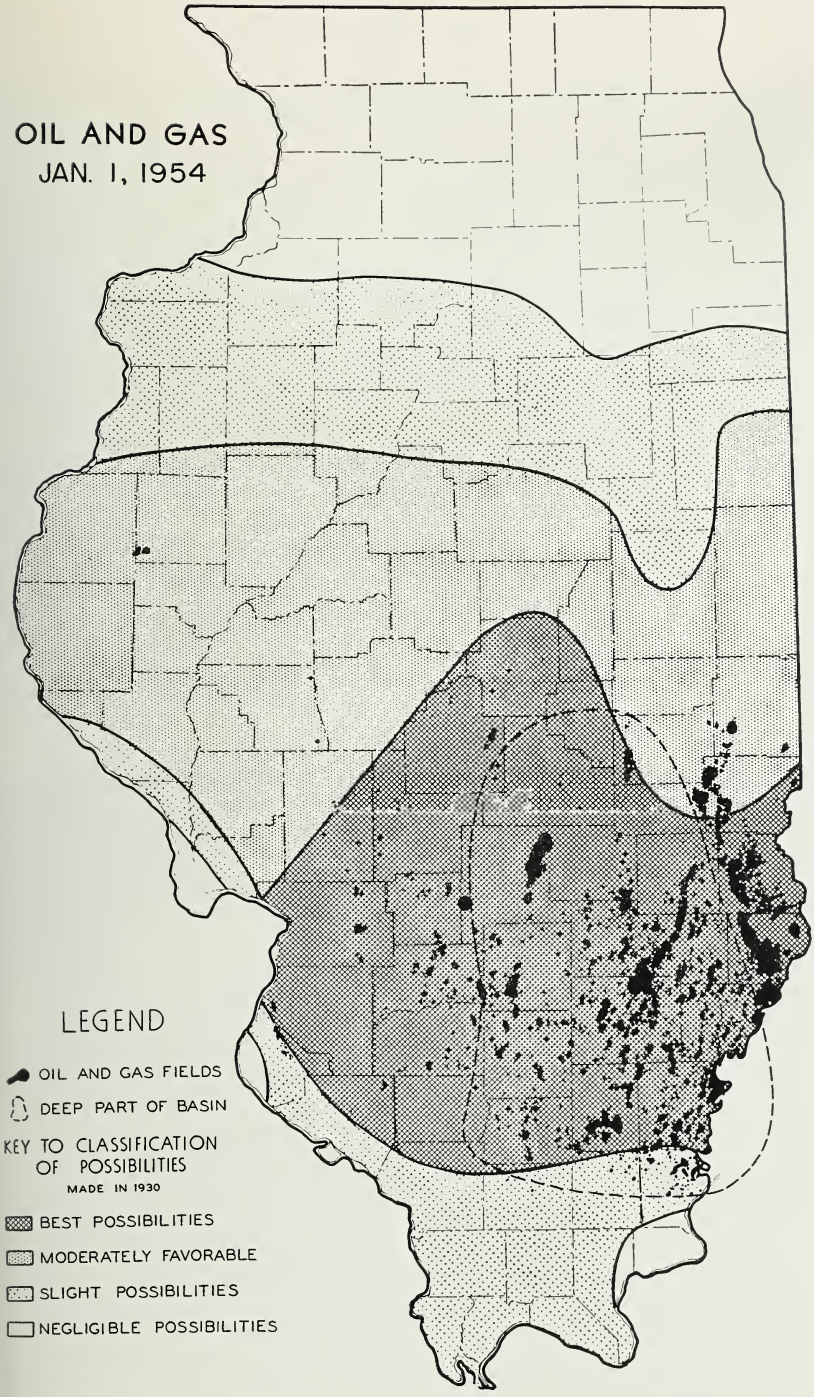
8. *The plant material in coal* has been the subject of highly specialized research. Fossilized spores from the plants which formed the coal originally have been separated and identified and have proved to be useful keys in the correlation of coal beds. "Coal balls" (rounded accumulations of exceptionally well-preserved fossil plant material) furnish abundant plant remains for examination and 171 such balls were sectioned, polished, and studied during the past year.

9. *A coal extract of potential medical worth* has been isolated in the Survey's laboratories. Following results of research done at the University of Nottingham, England, an investigation was undertaken on the solvent extraction from vitrain (one of the banded ingredients of coal) in Illinois coals of a substance which inhibits the growth of certain specific bacteria and fungi. Further research revealed that a substance having similar bacteriostatic properties can be extracted from lignite, subbituminous coals, and bituminous coals, as well as from certain Pleistocene and modern woods. This project has been carried on cooperatively with plant pathologists from the staff of the State Natural History Survey and reports on it have been published recently in *Science*. Now that the State Surveys have called attention to it, there are indications that the nature and value of this substance will be fully explored by competent medical, dental, pharmaceutical, and industrial institutions to determine any possible practical application of this material in combating diseases of man, animals, and plants.

10. *Improvement in quality of the coal purchased by the State* for its various institutions has resulted from the Geological Survey's sampling and analyzing coals for this purpose. Twice each year a member of the Geological Survey's chemical engineering staff makes the rounds of the 31 state institutions which use coal for boiler fuel and keeps the engineering staffs of those institutions informed on sampling and preparation methods. During the year covered by this report, 569 samples were received and analyzed.

Oil and Gas

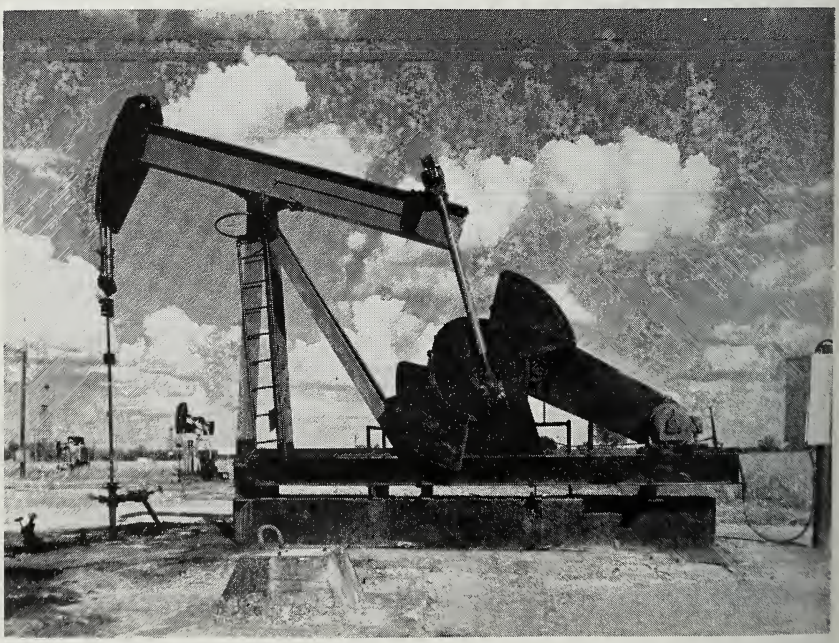
Illinois production in 1953 totaled somewhat more than 59 million barrels of oil valued at more than $171,500,000. This compares with 60 million barrels in 1952, a decline of only 1.6 percent. Proved reserves in the known pools of the State as of December 31, 1953 were esti-



This map, prepared by Dr. A. H. Bell, Geologist and Head of the Survey's Oil and Gas Division, anticipated by 7 years the discovery of oil in the Illinois Basin.

mated at 681,900,000 barrels, 14,300,000 more than at the beginning of the year. In the twelve months ending April 30, 1954, 32 new oil pools, one new (shut in) gas pool, 63 extensions to oil pools, and 21 new "pay sands" were discovered. An area in Macomb, Christian, and Sangamon counties, centered between Decatur and Mt. Auburn, has attracted considerable attention in recent months. A well drilled in July, 1953 produced oil from rocks of Silurian age and since that time other wells have been drilled in the area producing from Silurian-Devonian pay. This development is in line with the marked interest shown in the past several years in testing for production from rock horizons below those which have hitherto furnished most of the State's oil.

11. *Discovery of additional resources of petroleum* is critical to the demands of transportation, industry, agriculture, and our defense. The State Geological Survey very effectively assists in the search for oil by making available the immense amount of scientific information in its possession. Hundreds of thousands of well records and samples of drill cuttings and cores are in the Survey's files and more are added every year. Members of its scientific staff study, interpret, and correlate the geology revealed by these records; prepare useful maps, cross sections, reports, and production statistics; answer inquiries by letter, tele-



Pumping oil from a well producing from Devonian limestone in the Salem field.

phone, and personal conference; and help in every possible way to guide and inform operators, landowners, and interested citizens.

12. *New structure maps* are continually being made to further clarify the geologic picture in three-dimensional perspective, to help evaluate the likelihood of oil accumulation in various areas, and to guide operators in their drilling. A map showing the structure of the Trenton in Illinois was released in May 1954. This map showed sea-level elevation of the top of the Trenton over the entire State and will be useful to operators in determining the approximate depth to the Trenton at any location prior to drilling a test well.

A structure map of the southern two-thirds of Illinois, which is the major oil-producing area of the State, was published in 1943. The thousands of wells which have been drilled in this area since that time make revision of this map a major undertaking. Work accomplished on it during the past year has included (1) rechecking locations and data on the New Albany base map for fourteen counties in the southeastern quarter of the State; (2) searching the files for wells drilled to the Devonian or deeper—45 counties completed and data sheets for an estimated 4,000 tests prepared; and (3) studying sets of samples through the Devonian-Silurian section in the vicinity of the Tilden pool, Randolph County.

Other structural studies are currently in progress. Data from electric logs and from the examination of drill cuttings are posted on oil and gas development maps and structure contours are drawn on various key horizons. Such maps are in preparation for areas in Clinton, Marion, Jefferson, Perry, and Franklin counties and for an area in Randolph and Washington counties. A report on the structural history of the Centralia area was published in May 1954.

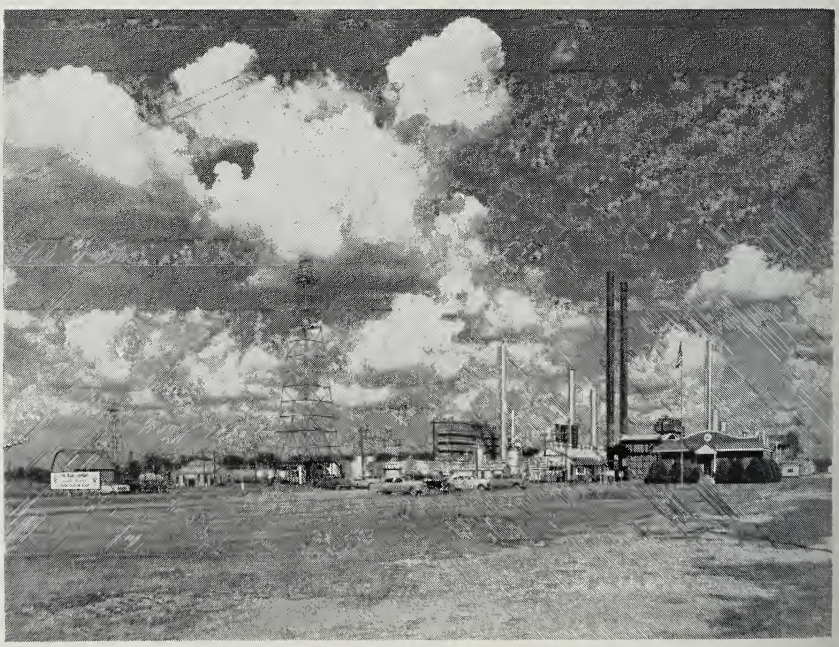
13. *Periodic reports.* Monthly reports on oil and gas drilling activities throughout the State are prepared and issued in mimeographed form. These reports are widely used by the petroleum industry, government officials, landowners, businessmen, and others interested in current oil field activity.

Special monthly reports are also prepared for the use of the Interstate Oil Compact Commission and for certain trade journals, news is furnished to the Illinois Oil and Gas Association for its monthly letter, and a monthly report is made to the Petroleum Administration for Defense on the amount of casing used by oil operators in the State.

Development maps on a scale of two inches to the mile, showing the location and current status of all wells drilled, have been prepared for 48 areas, each covering nine townships. Master copies on tracing linen are revised every three months and copies are available at the cost of blueprinting. Approximately 1,400 of these maps were distributed during the past year.

14. *Oil and gas developments in Illinois* are the subject of statistical analysis each year and the resulting report is published by the American Institute of Mining and Metallurgical Engineers and simultaneously reprinted by the Survey. Such reports have been issued without interruption since 1933 and comprise a valuable historical record of activities relating to oil and gas in Illinois since that time. The Survey also cooperates each year with the American Petroleum Institute Committee on Reserves for Illinois by furnishing the latest available data on estimated reserves for the State.

15. *Free information service* is rendered to landowners, professional geologists, and oil operators. A part of the basic data necessary to this service is directly filed with the Survey by oil companies in the form of driller's logs, drilling time logs, electric logs, and sample cuttings and cores in accordance with State requirements. A substantial amount of the data, however, has to be collected in the field, and two staff members devote full time to this work. One acts as an oil scout and in this capacity covers approximately the northern half of the State and attends the weekly meetings of the Illinois Basin Scout Association, which is a clearing house for current drilling information. The other collects cores and cuttings as well as samples of oil, gas, and brine from recently drilled wells and makes measurements of gas flow



The Texas Company's gasoline plant at Salem.

Diamond drill cores from deep rock formations being studied, at site of drilling, by a staff geologist of the State Geological Survey.

to determine gas-oil ratios. During the year covered by this report, 149 drill cores from 61 wells representing 4,000 feet of core were collected and examined; 90 brine samples were collected for analysis; rate of gas flow was measured from 26 drift gas wells and six bedrock gas wells; and 61 gas-oil ratios were checked, many of them upon request from the oil companies.

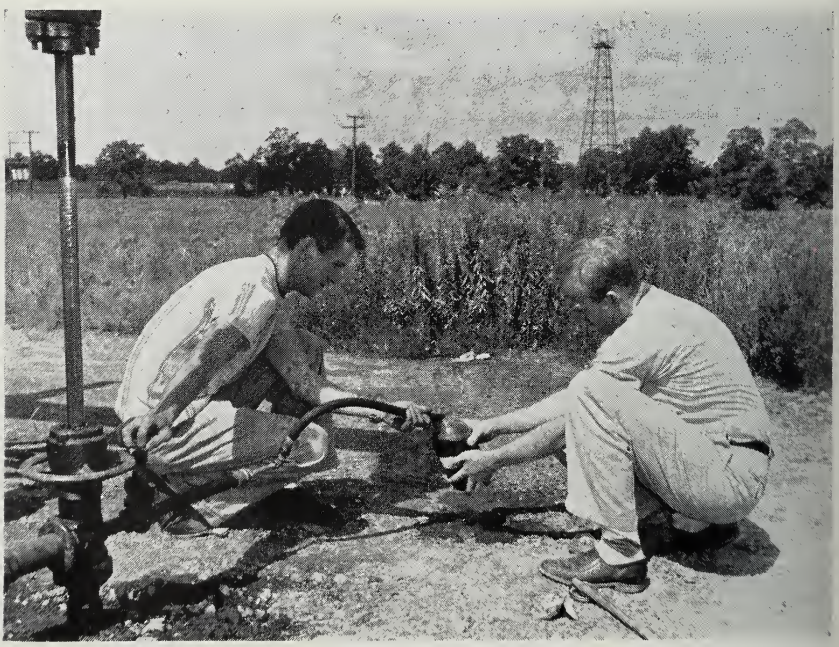
This service is rendered by letter, over the telephone, and in personal conferences. Approximately 1,500 requests for information were received and handled during the past year, some 500 of them by personal conference and telephone. Many inquiries concerning specific areas necessitate a review by a member of the Survey staff of all of the pertinent information available in the files and its presentation in a form understandable to the person making the inquiry. The Survey receives many expressions of appreciation of the prompt, courteous, and informative response to public inquiries.

Petroleum Engineering

It is of paramount importance that oil once discovered be extracted as completely as is economically possible from its natural rock reservoir. With the continuing high demand for petroleum and its products and the likelihood of eventually diminished reserves, the science of petroleum engineering is becoming increasingly important in the development of the nation's oil resources.

16. *Engineering data on water flood operations in Illinois* have been gathered by the Survey's Division of Petroleum Engineering and have been published both by the Survey and by the Interstate Oil Compact Commission. Water flooding as a method for secondary recovery of oil was introduced in Illinois a number of years ago largely as a result of the Geological Survey's recommendation. By this method water forced down in-put wells literally flushes out the oil remaining in the reservoir rock after pumpage has declined below the limit of economic production. The amount of oil produced in Illinois by this method in 1953 was approximately 12,500,000 barrels, which had an estimated value of $34,920,000, and constituted 21 percent of the total oil produced in the State that year. The amount of oil so recovered each year has increased steadily since 1941, when 30,000 barrels were recovered; the total produced by water flooding methods in the past 13 years is estimated at 54,400,000 barrels. It is apparent, therefore, that the secondary recovery of petroleum is an increasingly important factor in maintaining the State's production of oil at a high level.

A comprehensive study of the performance of water floods is in progress to correlate certain operating features of water floods with their consequent oil production in an effort to determine how the secondary recovery of oil may be made more efficient. Two aspects of the



Sampling crude oil for testing in the Survey's petroleum engineering laboratories.

problem which are currently receiving special attention are (1) the problem of predicting rate of oil production after a water flood is developed and has passed its peak and (2) the effect of rate of water injection on the recovery of oil. Effort is also being made to evaluate the effectiveness of "dump" flooding, a procedure whereby water-bearing formations overlying the oil-producing horizon are opened in selected wells and the water so released is "dumped" on the oil formations below to flush the oil toward adjacent wells.

17. *The physical properties of Illinois crude oils* are being investigated to obtain data on the flow of fluids through oil reservoirs in order to determine the relationships between the physical properties of crudes and the effect of water flooding; to correlate them with their geologic occurrence; and, if possible, to provide a practical means of predicting the physical properties of Illinois crude oils. Samples have been taken from selected wells producing from certain formations. Additional samples have been taken from the same wells at a later date to discover if physical properties vary in the same well from time to time. Samples have also been taken from wells producing from the same horizon but differently located structurally to determine the variability of physical properties of the same crude from place to place. This is a long-range project but should be fruitful of significant engineering information.

18. *Oil sand studies.* Research is in progress on the porosity and permeability of oil sands. Through the cooperation of various oil companies operating in Illinois fields, samples and cores of producing sands have been received. Another very important factor being investigated is the clay mineral content of the various oil sands. Certain clay minerals swell when wet and by clogging the oil sands can seriously endanger the success of a water flooding operation after the venture is underway. During the period covered by this report, samples of the Cypress sands from the Clay City Consolidated field, the Aux Vases sand from the New Harmony Consolidated and the Mill Shoals fields, the Casey sand from the North Johnson field, and Buchanan, Bridgeport, and Kirkwood sands from the Lawrence field have been analyzed for clay mineral content.

19. *Underground storage of liquid petroleum products* has become within the past two or three years an undertaking of great potential industrial significance. By this process billions of cubic feet of gas or hundreds of thousands of barrels of liquefied petroleum gases can be stored in natural underground reservoirs or in mined-out caverns at much less cost than in tanks above ground. Winter gas shortages can thus be avoided and great savings in steel can be realized. Geologic conditions underground, however, must meet very rigid specifications if any such undertaking is to prove feasible. As a result of the rapidly increasing use of underground storage methods over the entire United

States, the Interstate Oil Compact Commission has recently set up study committees in a number of states to follow developments, and a member of the Survey's staff has been appointed chairman of the Illinois committee. Several major underground storage projects have either been completed or are underway in Illinois, and the Survey has been called upon from time to time for geologic and engineering data.

Clay and Clay Products

The value of clay and clay products produced in Illinois in 1953 amounted to an estimated $47,000,000, an increase of somewhat more than 10 percent over 1952 value. Refractories accounted for some $11,960,000, and the values of other clay products were: common brick, $6,759,000; face brick, $6,922,000; other structural clay products (paving block, sewer pipe, drain and structural tile, terra cotta, etc.), $4,670,000; and pottery, $15,848,000.

20. *Fundamental discoveries in clay mineralogy* are outstanding achievements of the Illinois State Geological Survey. More than twenty years ago the Survey inaugurated a comprehensive program of research on the physical, chemical, and atomic structure of the group of minerals called clay minerals. Prior to that time comparatively little was known concerning the internal mineralogic structure of clay—one of the least spectacular but most valuable of the State's mineral resources. Since that time information has been obtained which has revolutionized our knowledge of the many kinds of clays, their uses, and beneficiating practices, information significant both to science and to the solution of practical industrial problems. Because of its work the Survey has become known throughout the world, and visitors from many foreign countries have come to the Survey's laboratories to observe its research techniques.

21. *Service of great value to the clay industry* has been rendered as a result of this research. Industrial processing problems have been solved, products have been improved, new products have been made, and new prospecting methods have been developed. The kinds and proportions of clay minerals in a deposit, the textural character, the impurities, the methods of beneficiating and processing, and the nature of the products that can be made are now readily ascertainable.

The knowledge gained through research has given a better understanding of the problems encountered in ceramics as well as of those encountered in mining, in the building of highways and dams, and in the construction of foundations for large buildings. During the past year the Survey's assistance was sought in connection with squeezes in a coal mine east of Collinsville which had driven operators from several areas of production. Special study was given to clay minerals in roof shales of coal mines, and some 20 samples of clay and shales were

Airplane view of Illinois Clay Products plant in northern Illinois.

studied for industry and 29 for individual citizens of the State. This service is made possible through the use by competent scientists of petrographic microscopes, X-ray, spectrograph, thermal analysis apparatus, and other specialized equipment.

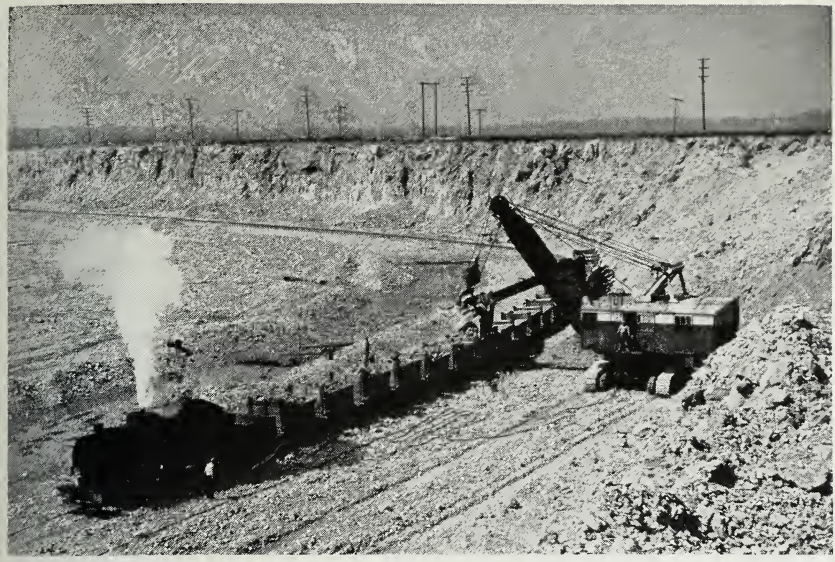
22. *The clay and shale resources of the State* are being "inventoried" by Survey geologists. Samples are collected in the field and analyzed in the laboratory by the techniques previously referred to. The data derived are classified and indexed, and they enable the Survey to guide operators in locating deposits of material having the particular properties required to meet industrial specifications. During the year covered by this reyort 262 samples of clay and shale from cores and outcrops were studied.

A special report on the clays of western Illinois, for which field work and laboratory testing were completed last year, is nearing completion.

23. *The safety and permanence of foundations* depend to a great extent on the underlying earth materials. The clay mineral content of these earth materials is in many instances the controlling factor, and it is essential for the construction engineer to know how the foundation materials will react in the course of time. The Geological Survey has been conducting special investigations on the behavior of different clay minerals under varying conditions of load and moisture. Chemical studies have revealed that the base elements (such as calcium or sodium) in the composition of clays are "exchangeable." Physical studies have revealed that the liquid limit of a sodium clay high in montmorillonite (one of the clay minerals) is 2½ to 3½ times that for a calcium montmorillonite. The practical application of this seemingly obscure knowledge is that after concrete has been poured into or onto a sodium montmorillonite clay, calcium from the concrete begins to exchange for sodium in the clay. Eventually the plastic range of the clay will be reduced to about ⅓ of the original, the clay will become fluid, and the dam or road will be destroyed or the building damaged or even destroyed.

Rock and Rock Products

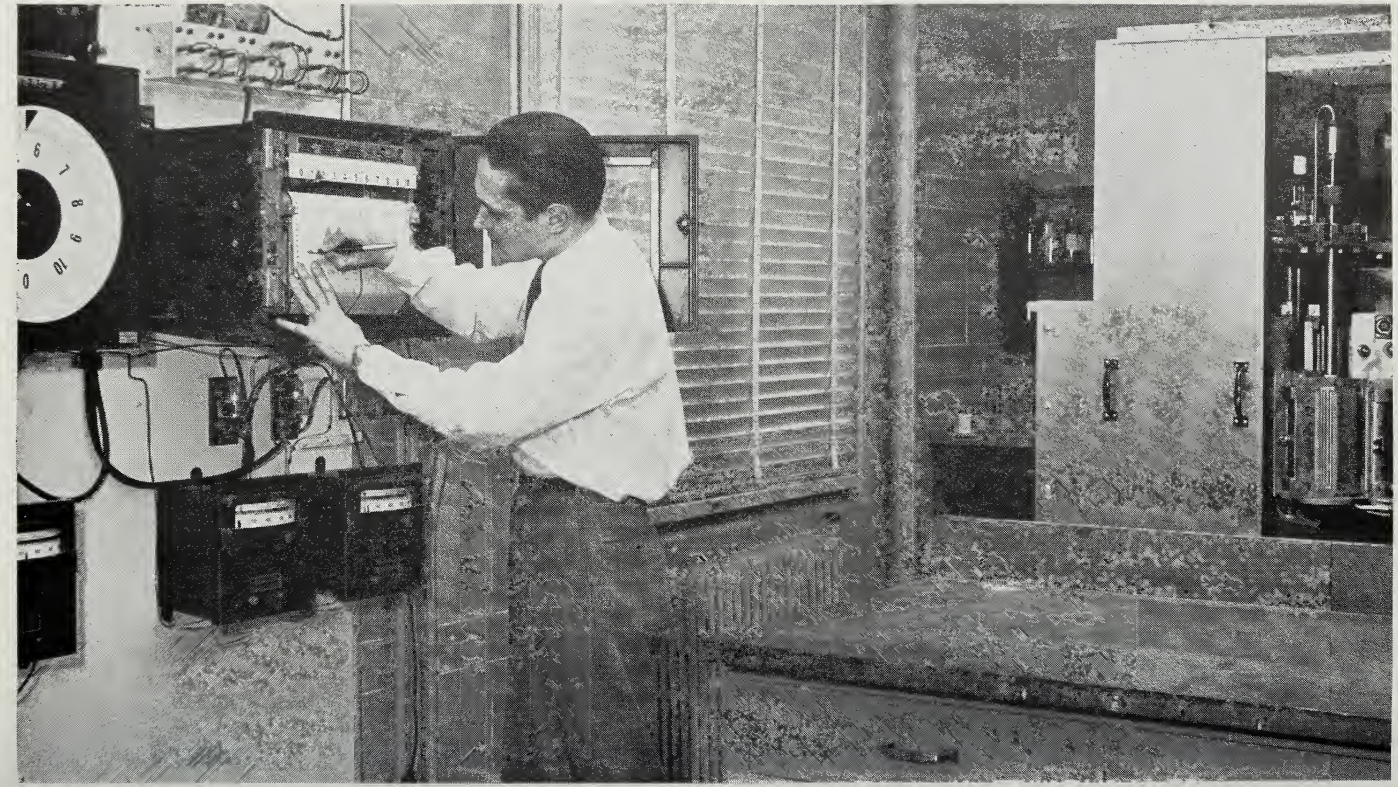
Rock and rock products produced in Illinois include limestone and dolomite, lime, cement, silica sand, ground silica sand, and sand and gravel. Approximately 400 plants operating in Illinois in 1953 produced rock products valued at an estimated $77,000,000, an increase of more than 20 percent over 1952 value. This high production of rock products may be even further increased in response to the demand for road metal, cement, and sand and gravel if the construction of toll highways in Illinois becomes a reality.



Loading limestone at the rate of about one car per minute in the Material Service Corporation's quarry at Thornton.

24. *Many and varied uses* are made of the limestone and dolomite of Illinois. In 1953 approximately 22,000,000 tons of Illinois stone was produced and marketed for use as building and road materials, for the liming of soil, the manufacture of lime, and for flux stone in the steel industry. The Geological Survey has for many years been assembling field and laboratory data on the stone resources of the State, and is able to furnish information on the extent, thickness, and quality of rock formations. Its assistance is continually being sought by the stone industry, and during the past year the Survey has come to the aid of stone companies and quarry operators in all areas of the State, in some instances helping them to locate new and better deposits, in others preventing their undertaking costly test drilling at locations where no better material would have been found.

25. *The physical and chemical nature of limestone and dolomite* is the subject of research in the Survey's laboratories to obtain a better understanding of the changes that take place either in the weathering of the stone or in the course of industrial processing. Such fundamental information is needed to meet the new refinements of commercial specifications. Systematic sampling and analysis is continually in progress. During the past year some 67 samples taken from outcrops of the Shakopee dolomite in the vicinity of Utica were studied. Information derived from analysis of these samples proved very helpful in assisting the operator of a local quarry to understand and evaluate the



Controllers and recorders (left) **and high pressure and temperature apparatus** (right) **used in studying the physical and chemical nature of Illinois limestones and dolomites.**

possibilities for producing a greater quantity of stone of superior physical quality. Some 112 samples were taken from various localities in the vicinity of Alton, where considerable interest has been shown in recent years in regard to additional quarry sites. Insoluble residue studies on these samples revealed that the stone from most of the exposures is of acceptable quality for a number of commercial uses.

An investigation has been begun of the character of the organic material in the insoluble residues of typical limestones in order to answer questions from the industry regarding the nature of this material.

The kind and amount of trace elements such as zinc, copper, manganese, boron, cobalt, and iodine in the limestones and dolomites used for agricultural limestone and in mineral feeds for stock are of considerable significance in connection with plant and animal nutrition. The trace elements are therefore important to the Illinois quarrying industry which produces agricultural limestone and stone for mineral feeds. The quarry man wants to know how to sample a deposit to determine its trace element content, how consistent the percentages of trace elements are in different parts of a deposit, and how uniform the trace element content is in the stone produced commercially from day to day. Through systematic sampling and analysis of quarry rock the Survey is attempting to answer these questions for the operator.

Water-soluble salts found in Illinois limestones and dolomites either as solids between the crystals of the rock or in minute fluid inclusions within the crystals have also been studied. A preliminary Report of Investigations entitled "Water-Soluble Salts in Limestones and Dolomites," published in May 1953, has brought much favorable comment from the industry both in this country and abroad. Data so far collected strongly suggest among other things that the limestone used for making mineral feed for stock is the source of excess chloride, a possibility that had not been previously considered. A large Illinois producer of pulverized limestone requested a study of the water-soluble salt content of his various commercial grades of limestone powders. It was discovered that a greater amount of salts could be water-leached from the fine limestone powders than from the coarse powders. Current work on water-soluble salts deals primarily with the effect of heating on the chlorides, including sodium chloride, which occurs in the fluid inclusions, since it is known that, in lime burning, sodium chloride naturally present or added to some limestones or dolomites favorably influences the character of the resulting lime.

Studies are also in progress on the effect of crushing and screening on the quality of certain limestones. Results so far from experiments on the dolomitic Platteville limestone suggest that the dolomite in the limestone exists as small crystals or crystal clusters which tend to break up during crushing and to be concentrated in the fine sizes. Further work

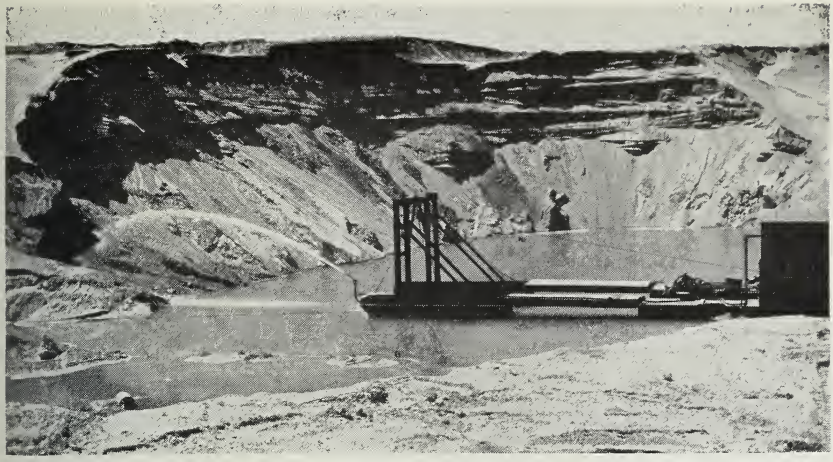
is needed to demonstrate commercial application of results, but it seems likely that the use of certain Illinois limestones can be broadened by some comparatively simple physical means.

26. *The maintenance of soils* so essential to agriculture is achieved partly through the use of agricultural limestone. Illinois produced more than 3,000,000 tons of stone for this purpose in 1953. The Geological Survey makes free tests of samples submitted by county farm advisers, operators, and landowners, and reports promptly on the quality of the stone for agricultural purposes.

27. *The siliceous mineral resources of the State* receive constant study. A report was published in August 1953, dealing with the resources and the chemical and physical characteristics of silica (tripoli), ganister, novaculite, calico rock, novaculite gravel, and other gravels in extreme southern Illinois. This was the first published report on these resources, and operators have stated that it contains much valuable and concise information which will serve as a guide to the industry.

In response to several requests for information regarding western Ogle County as a source of silica sand for glass manufacture and for use in fracturing processes currently much used in oil production, a

Hydraulic mining of silica sand in Ottawa Silica Company's quarry at Ottawa. Pressure at the nozzle is reported to be 110 pounds per square inch.



Dredging sand and gravel near Pekin (McGrath Sand and Gravel Company of Pekin).

special study was undertaken of the St. Peter sandstone in that area. The sand lacked coarseness of grain for the fracturing process but one outcrop examined appeared to have possibilities for glass sand.

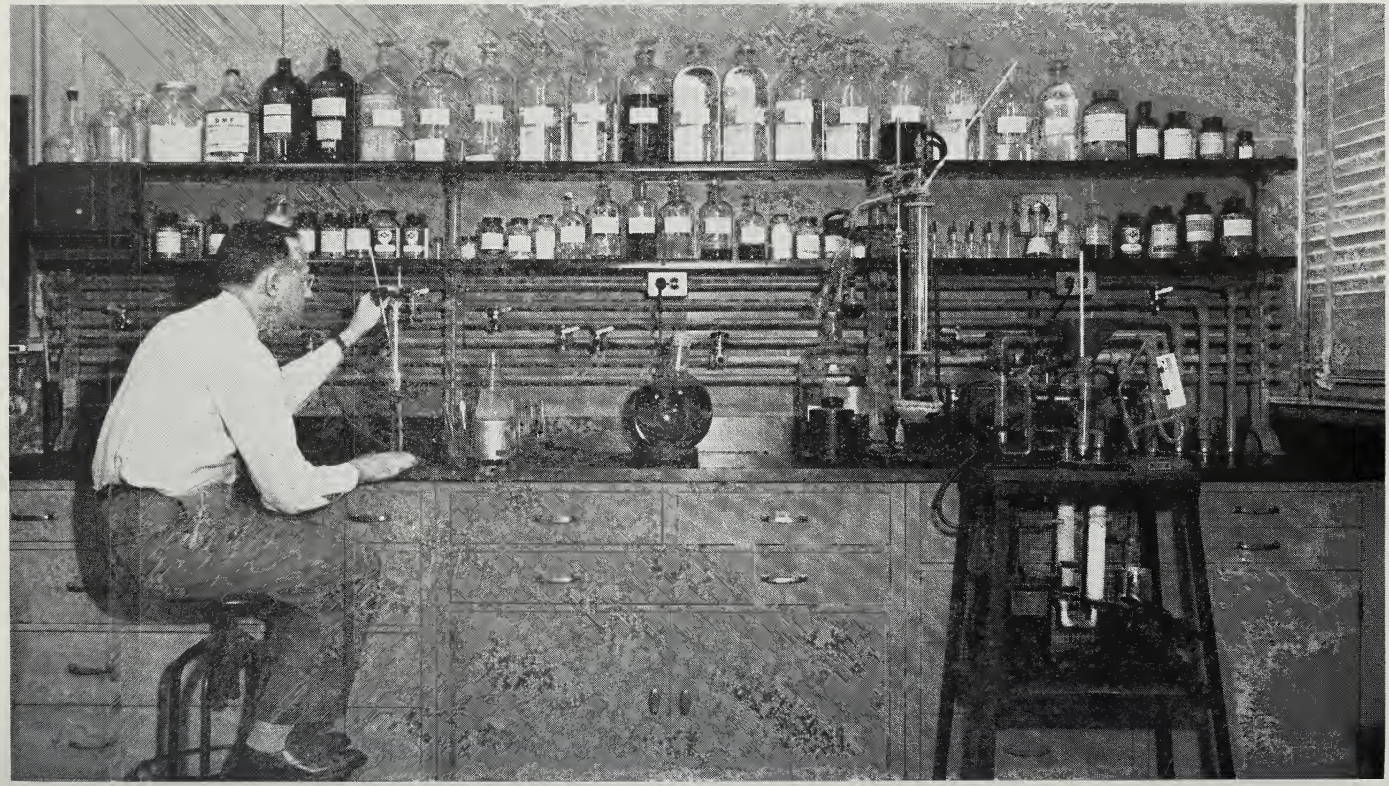
A method of sub-sieve particle size analysis used by the Survey for testing samples of silica developed information of such value for control purposes that one silica producer in southern Illinois has installed equipment for doing his own testing.

Sand and gravel is in constant demand, and the Survey assists operators throughout the State in locating and testing deposits having the particular properties needed for any one of a wide variety of uses.

28. *The chemistry of silicate melts* (mixtures of lime, magnesia, alumina, and silica at high temperatures), especially those which may be derived from rocks and minerals commercially mined or quarried in Illinois, is the subject of continuing research to secure data useful in the study and solution of problems encountered in the manufacture of mineral wool and of ceramic and metallurgical products of diverse character. Current studies are concerned especially with the effect of fluorspar on the viscosity of porcelain enamels, and further work will be concerned with the electrical conductivity and surface tension of porcelain enamel-type melts.

Fluorspar

Fluorspar produced in Illinois during 1953 is estimated at about 181,000 tons, valued at about $9,000,000. More than half the spar produced in the United States comes from the Hardin-Pope County area of southeastern Illinois, but the industry has had severe competi-



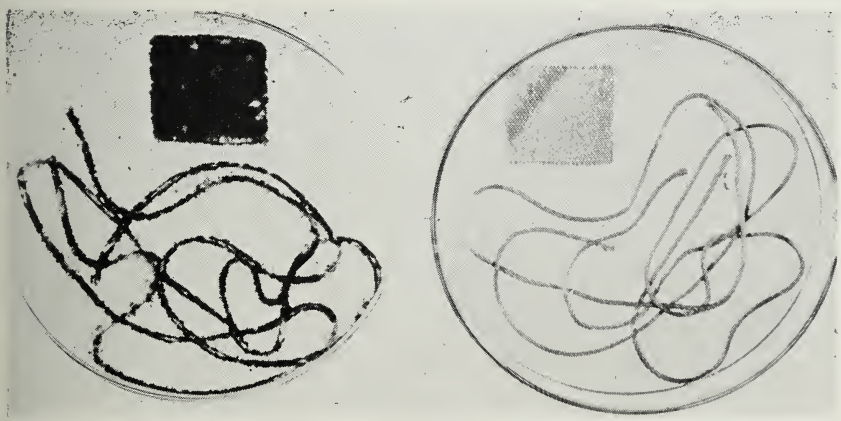
One of the Geological Survey's laboratories for research in fluorine chemistry.

tion from imported Mexican spar, and 1953 production is off some 12 percent from the 1952 level. Though still in demand as a flux in the manufacture of steel (formerly its principal use), nearly half the fluorspar produced in Illinois now finds its way to the ever-expanding chemical market where it is used for widely varied purposes including the manufacture of refrigerants, insecticides, aviation gasoline, fluorocarbon plastics; in medical research; and in the development of atomic energy.

29. *The search for new deposits of fluorspar* continues and Survey geologists assist operators and prospectors by interpreting results of core testing and by guiding exploration. The recent discovery of an ore body in a hitherto unprospected area near Spark's Hill has led to active mining in the area. The Survey has cooperated fully in this matter by interpreting the results of prospect drilling and other geologic information. Similar assistance has been given in connection with renewed prospecting in an area near Dixon Springs in Pope County and geological advice and assistance have been given to various operators in the district.

30. *Fluorine chemistry* is a highly specialized field of research in which the Illinois Geological Survey has achieved international recognition. The primary objectives of this research are to extend the uses of fluorspar in the chemical industry and to develop practical methods for synthesizing organic fluorine compounds.

Many important applications of the results of this work have already been made. Work undertaken by the Survey under a contract with the U. S. Air Force and the University of Illinois on the synthesis of organic fluorine compounds for fungicidal purposes was brought to satisfactory completion during the past year. Five of the fifty com-



New organic fluorine fungicide, developed in Survey's laboratories, protects cotton fabric from deterioration by fungi. Left, untreated cotton—severe damage; Right, treated cotton—no damage.

pounds prepared by the Survey and screened as to properties by the Natural History Survey are among the most potent fungicides tested by the Air Force. They have been found to protect effectively plastics and fabrics against fungus deterioration, they do not cause adverse physical changes in most materials, and no skin irritation was observed with impregnated fabric patch tests on humans. Some idea of the practical value of this fundamental research may be gained from the fact that the national annual damage from deterioration amounting to some $12,000,000,000 is caused principally by mildew and fungus rot. Fluorine compounds furnished by the Survey are playing a significant role in cancer research at the University of Wisconsin's Medical School. It now appears that they will shed some light on the mechanism of cancer induced by chemical means. Samples of fluorine fungicide have also been furnished to the Illinois Natural History Survey for field testing in connection with the extensive Illinois gladiolus-growing industry, and results have been very promising.

Zinc and Lead

In 1953 Illinois produced about 14,600 tons of zinc metal valued at $3,175,000, and 3,320 tons of lead valued at approximately $884,000. Lead and zinc mining around Galena in northwestern Illinois was an important factor in the early development of this part of the Middle West during and after the Civil War but was virtually abandoned around the turn of the century. Largely as a result of the Geological Survey's assistance in exploration in 1943 when wartime need for these minerals was great, this area has become the scene of renewed and profitable mining activity.

31. *Prospecting for new ore deposits* is effectively encouraged by service rendered from a branch office of the Survey at Galena where a small staff is stationed. Survey geologists carry on active field investigation and research, study and interpret cores and drill cuttings, and personally confer with operators and individuals concerned with mining developments.

During the past year cuttings from 122 prospect drilling and eight water wells were studied. Sixty-nine of the prospect borings contained significant quantities of minerals, and estimates were made of the amount of zinc, lead, and iron in these borings. One hundred and sixty-seven conferences were held with members of the northwest Illinois mining industry and 185 conferences with landowners and individuals interested in zinc and lead resources. In spite of the fact that declining prices for zinc and lead have led to the closing of some of the mines, the number of conferences held both with representatives of the industry and with landowners shows a marked increase over similar conferences in the preceding year and indicates a continued lively interest in lead and zinc production in that area.

32. *Structural mapping* to aid in exploration was continued during the 1953 field season particularly in the Elizabeth region, an abandoned but formerly important lead and zinc producing area about 15 miles southeast of Galena, and in a small area near the Sinsinawa River three miles west of Galena. Maps and cross sections showing the position of the ore bodies and their relations to the geologic formations of the area are available for public reference in the Galena office and prove very helpful to the prospector.

33. *The origin of the ore deposits* and their geologic relationships are continually being studied both in place in the mines and under the microscope in the laboratory. A more complete understanding of the genesis of the ore bodies may be the means of discovering additional clues which will be useful in finding new deposits. Field and laboratory investigations are also in progress to determine the feasibility of spectrographic analysis for trace elements in locating mineralization "halos" at the surface over ore bodies. Laboratory procedures have been perfected, some samples have been analyzed, and further work is planned.

Groundwater Resources

All mankind needs water whether it be in only sufficient quantity to sustain life or in supply adequate to water stock, to irrigate fields, or to care for the needs of large industries or of entire communities. Problems associated with its presence or absence underground are primarily geological, and the search for it receives constant attention by the Geological Survey—some eight geologists devoting their entire service to this problem.

34. *Special reports* are prepared on the geology of specific localities where water is needed. These reports tell the driller or landowner what kind of rocks underlie the area, in which of them water is likely to occur, and at what depth it will probably be found. Recent drought conditions have greatly increased the number of requests for this type of information, and the number of such reports prepared by the Survey during the past year was increased by 69 percent and totaled 503 as compared with 296 the previous year. Of this larger total, 224 were reports prepared for private citizens, 50 for industrial installations, 93 for municipalities, 32 for public institutions, and 104 involved technical correspondence on various geologic problems related to groundwater.

Of particular interest among these services, perhaps, is the assistance the Survey has been able to give the cities of Decatur and Shelbyville in attempting to locate additional municipal supplies. In both areas very promising deposits of buried sand and gravel have been located and test drilling by the cities is underway.

35. *Electrical resistivity surveys* are made to discover the location of underlying gravel deposits which might carry large quantities of water. The Survey pioneered in this method of locating water supplies, which has proved very effective in directing the placement of test holes and has saved much needless and expensive testing in barren areas. During the past year 76 such surveys were made as compared with 47 during the previous year, an increase of 62 percent. Surveys were made for 36 municipalities, nine each for industries and for schools, and 22 for private individuals, most of them farmers.

36. *The geology of special areas* as it relates particularly to groundwater resources is the subject of special field and laboratory study. A report on the groundwater geology of the East St. Louis area is nearing completion, as is a report on the groundwater geology of Lee and Whiteside counties. A study has also been made of sandstone aquifers in White County, and an investigation of the groundwater geology of Winnebago and Ogle counties is in progress.

37. *Geophysical methods of exploration* other than by electrical resistivity have consisted principally of work with a shallow refraction seismograph. Miniature earthquakes are created by exploding small charges of dynamite at shallow depths (6 or 7 feet) and the course, intensity, and speed of the waves so generated are recorded. Geologic interpretation of data so far obtained indicates the usefulness of this method in locating bedrock surface and even in picking up differentiations within unconsolidated materials. It has proved useful in locating bodies of sand and gravel likely to be the source of groundwater and has been of value for this purpose particularly when used in conjunction with electrical resistivity surveys.

38. *Assistance to drillers* in evaluation of their testing is rendered by Survey geologists through the microscopic examination of drill cuttings and mechanical analysis of sand.

39. *Cooperation with the Illinois Water Well Drillers Association* has been continued. The Geological Survey cooperated in the founding of this association in 1927 and has continued active cooperation by visiting the operations of water well drillers, supplying them with sample sacks and log books, collecting well samples from them, and otherwise aiding them in water supply development.

Engineering Geology

Geologic conditions are frequently the determining factor in engineering problems encountered in highway construction, in the selection of suitable sites for reservoirs and dams, in testing the stability of earth materials for foundations for large structures, and in determining char-

acter and strength of rock strata as it may affect the planning of underground excavation.

40. *Scientific service* is rendered in the form of geologic information relating to engineering problems of diverse character throughout the State. As a matter of policy the Survey restricts its assistance to furnishing geologic information basic to the engineering aspect of the problems which are brought to it and avoids competing with private engineering consulting practice. Field and office conferences are held, and where necessary earth materials are sampled and studied and reports are prepared.

During the past year the Survey's assistance has been sought in connection with favorable sites for a new factory near Peoria; geologic conditions above mined-out coal areas with reference to sites for industrial plants; farm damage allegedly due to drainage diversion; soil and drainage conditions at various home sites; engineering data on the LaSalle anticline; effect of the removal of a rock ledge on the regimen of the Kankakee River; elevation and character of bedrock along a portion of the Mississippi River; geologic conditions of the foundation for a proposed tower and anchors for a radio station at Quincy; the geology at the site for an addition to the Rock Falls High School; and favorable sites for numerous ponds and lakes to be created by earth dams at various localities in Champaign, DuPage, Effingham, Fulton, and Vermilion counties.

Cooperation was extended to Federal and to other State agencies throughout the year. Samples from test borings were studied and a report was prepared on the dam site in Redhills State Park, Lawrence County, for the State Department of Conservation; assistance was rendered to the State Division of Waterways in connection with geologic foundations of the hydro-electric company dam across Fox River at Dayton; a report was made on the subsurface geology along the proposed new U. S. Route No. 66 southeast of Edwardsville; assistance was given to the State Natural History Survey in connection with the possibility of creating a small fishpond in Vermilion County; test boring samples were examined from the site of the new law building at the University of Illinois and of the new State Office Building in Springfield.

Scientific Research and Mineral Resource Records

Many practical problems related to the discovery and development of mineral resources owe their solution to long-range patient research of a basic nature in geology, chemistry, and physics carried on in the field and laboratory through the years.

41. *Microscopic examination of drill cuttings* from wells and test holes reveals the identity, character, thickness, and extent of rock forma-

Microscopic study of drill cuttings reveals the nature and succession of underground rock formations. Work of this type is essential to the discovery of mineral deposits.

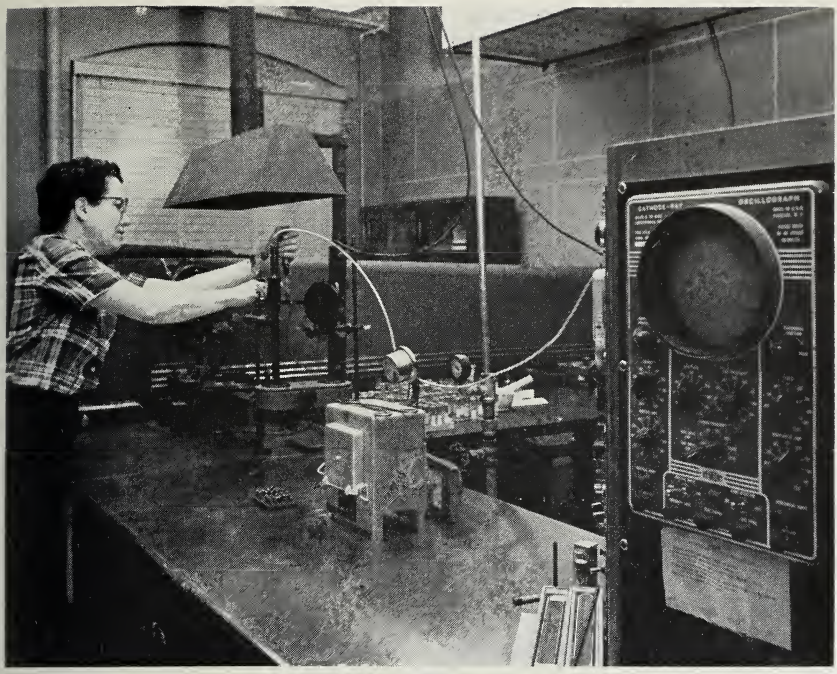
tions deep underground. Data from these studies are of inestimable value in the correlation of rock strata in connection with the search for oil and gas, coal, and other valuable mineral deposits, and the Survey is continually called upon for the interpretation of well records. During the past year 19,960 samples from 247 wells representing a total footage of 89,978 feet were studied and described in the Survey's "subsurface" laboratory. In addition to the drill cuttings, cores from 22 wells (totaling 7,652 feet of core) were examined microscopically, recorded, and filed. Sample study logs of the wells and cores are prepared and furnished to the operators and copies are placed in the Survey's files. The samples themselves are labeled, assembled into sets corresponding to each well log, and systematically filed. Nearly a thousand such sets from as many wells were filed during the past year, bringing the total number of sample sets on file to 24,204.

42. *Information basic to the discovery of mineral deposits* depends upon studies such as those just described and also on field examination of rock formations where they are exposed at the surface, the use of lithological features and fossil content in the identification and correlation of rock formations, and other investigations which can be adequately carried on only by highly trained geologists. During the past year a detailed study was completed on the Cambrian sandstones, which are important water-bearing sands in Illinois; examination was made of a core of rocks of Ordovician age in which the zinc and lead deposits of northwestern Illinois occur; extensive field investigations were made of outcrops of Silurian strata which contained fossil coral reefs, which are frequently reservoirs for oil and gas where they lie deeply buried in the Illinois Basin; samples of Devonian dolomites from 40 wells in central Illinois were examined; and considerable attention was devoted to formations of Mississippian age, in which are found our most productive oil sands.

Pleistocene deposits, laid down during the glacial period, are the subject of special investigation in field and laboratory. These deposits are of particular significance in connection with sand and gravel production, recovery of groundwater, manufacture of common brick and tile, and the classification and mapping of soils. The preparation of a comprehensive report on the Pleistocene of Illinois is in progress.

43. *Spectrochemical studies of geologic materials* constitute another modern and highly specialized approach by the Survey to the determination and identification of minute amounts of mineral substances which frequently have an important bearing on the properties and use of the rocks in which they occur. During the past year 155 samples were analyzed. Of these, 43 were limestones, dolomites, and clays analyzed quantitatively for major, minor, and trace constituents; 20 were clays analyzed for major constituents only; 21 were coals and

A part of the Mineral Resource Records room, where the logs of oil and water wells and other data on the mineral resources of the State are carefully filed for ready reference.



Spectrochemical analyses of minerals are made by a highly trained physicist in spectroscopy.

coal ashes analyzed for germanium; 12 were sand and gravel analyzed for major and minor constituents; 46 were qualitative or semiquantitative analyses made to answer questions of various kinds related to the presence, absence, or approximate amount of various constituents; and 13 were miscellaneous to determine major differences in constitution which might explain differences in properties.

44. *Chemical analyses* are performed to obtain detailed chemical data essential to many aspects of the Survey's work. During the period covered by this report, analyses were made on 1,032 samples of coal and coke (566 of which were for the State Department of Purchases and Supplies), 83 samples of rock, 77 samples of brine, 63 samples of gas, and 20 samples of oil. In addition some 70 samples were analyzed in the special microchemical laboratory.

45. *Research data serve their purpose* only if they are readily and permanently accessible. A special Mineral Resource Records Division, staffed by eight full-time persons, devotes its entire time to the systematic cataloging and filing of incoming technical research data and to furnishing information. These files contain more than 134,000 well log records, more than 32,000 electric logs, some 3,700 lantern slides, and

other valuable research materials including manuscripts and field notes. The division also maintains a special map library which is continually growing. Approximately 5,500 geologic and special maps are filed here in addition to some 11,500 topographic maps, more than 1,500 of which were received during the past year. Most of the map files are open to the public and copies of most of the well logs are available for lending purposes. During the past year more than 6,400 logs were lent to the public and nearly 600 people visited the files to obtain data.

The Geochemistry Section of the Survey has in its files chemical analyses of 18,908 samples, which include: coal, 11,020; rock, 3,875; gas, 919; oil, 495; brine, 1,459; and microanalysis 1,140.

Mineral Economics

The competitive factors and economic trends in mineral production, transportation, and marketing are critical in industrial development. Through the work of a mineral economist with a small staff of assistants to compile data for analyzing these problems, the Survey furnishes economic information to mineral operators, producers, manufacturers, railroads, chambers of commerce, and financial organizations throughout the State.

46. *The Midwest solid fuel situation* received particular attention during the past year and a paper on this subject was presented before a joint meeting of the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers in Chicago in October 1953.

47. *Conservation of mineral resources* is a matter of concern and many inquiries on this subject are received. A special report was completed during the past year and is currently in press.

48. *The competitive effect of western Kentucky coal* on the Illinois coal industry has been the subject of special study and a report is nearing completion.

49. *Annual reports* on the Illinois mineral industry are prepared which give statistics of production and interpretation of them. This work is carried out with the cooperation of the U. S. Bureau of Mines, the U. S. Bureau of the Census, and the State Department of Mines and Minerals. These reports, the first of which was published in 1931, constitute an uninterrupted record of Illinois mineral industry since that date.

Topographic Mapping

50. *Topographic maps* for somewhat over 95 percent of the State have now been prepared as the result of a systematic program of mapping which is carried forward each year in cooperation with the U. S.

Geological Survey. Through the progressive attitude of Illinois legislators in regularly appropriating funds to carry on this work (funds so appropriated are matched dollar for dollar by the Federal government), this ambitious but very important program is nearing completion. It is estimated that at the current rate the first topographic mapping of the entire State will be completed in four years.

During the past year 376 square miles of territory were mapped topographically in the field on a scale of one inch to the mile, twenty miles of transit traverse were run, and five traverse stations were set.

In addition, the U. S. Geological Survey with non-cooperative Federal funds mapped topographically in the field 627 square miles, mapped photogrammetrically 435 square miles, revised in the field 1,442 square miles, and revised photogrammetrically the mapping of five quadrangles, all on a scale of 2½ inches to a mile.

Three new quadrangle maps on a scale of one inch to the mile, one new quadrangle map on a scale of 2½ inches to the mile, and reprints of seven quadrangle maps on a scale of one inch to the mile and one quadrangle map on a scale of 2½ inches to the mile were published by the Federal Survey during the past year.

Public Service and Educational Extension

51. *Public information.* Careful attention is given to every inquiry received whether it be from a school child, from a Boy Scout working on a merit badge, or from a large industrial corporation. Thousands of requests are received every year and each one is handled by the staff member best equipped to furnish the information needed. Letters are received each year from individual citizens, from mineral operators, school teachers, chambers of commerce, village and city councils, and large commercial organizations expressing appreciation of the prompt and courteous service received from their State Geological Survey.

52. *Educational extension.* For the past 25 years a special division of the Survey has been rendering educational extension service throughout the State. This service includes the organization and leadership of field study conferences for science teachers; free identification of mineral specimens; informative correspondence with teachers and citizens; occasional lectures to organizations; the distribution of free rock and mineral collections to schools within the State; and educational exhibits at State and county fairs and special scientific meetings. Every effort is made to assist the science teachers of the secondary and primary schools of the State in the technical and cultural education of our young people.

During the past year 295 collections of typical rocks and minerals of Illinois were distributed on request to schools, Scout troops, and

public organizations throughout the State, and requests for information or for the identification of mineral specimens totaled over 800.

Regularly scheduled earth history field conferences, designed primarily for science teachers but open to all interested persons, were held in six widely separated areas. Mimeographed guide leaflets are prepared for each trip and there are now 46 such reports available to teachers, students, and citizens. In addition to these annually scheduled trips, five special field conferences were conducted for various science clubs and local geologic societies. Eight special lectures were given to conservation workshops, local nature clubs, and professional societies, and special exhibits were prepared for the State Fair and for several national professional meetings.

RESEARCH FACILITIES

The physical facilities of the Survey for research on mineral resources are probably not excelled in any comparable institution. The following is a summary of some 40 laboratories:

Geological Resources Section

Five laboratories for coal research: one in mining geology; one for megascopic, microscopic, and thermal analytical studies of coal; two for paleobotanical research on the botanical constituents of coal; and one for the study of Pennsylvanian stratigraphy and the preparation of coal-resource maps.

One laboratory for petroleum engineering research for studies of fluid flow through porous media and related problems.

Four laboratories for the study of industrial minerals: one moulding-sand laboratory for testing moulding sands and clays for bonding moulding sands; one for fundamental research on the basic mineralogy of dolomites and limestones; one for studies of the character, composition, and uses of limestone, dolomite, sand, gravel, silica, and other industrial minerals; and one for the microscopic study of zinc, lead, and fluorspar ores and of limestone, dolomite, and other industrial minerals.

Four laboratories for research on clays and clay mineral technology: two for differential thermal analyses; and two for testing the physical properties of clays in relation to soil mechanics, ceramic utilization, recovery of petroleum, and other engineering problems.

One laboratory for research in geophysics and on geophysical equipment, including apparatus for electrical resistivity surveys, radio transmission through geological formations and seismic surveys; also used for research on samples from water wells.

Three laboratories for research in stratigraphy and areal geology: one subsurface-geology laboratory for the study of samples of drill cuttings and preparation and study of insoluble residues from calcareous rocks; one laboratory for the study of diamond drill cores and the composition of rocks; and one laboratory for paleontologic research involving the identification of fossils and their use in stratigraphy.

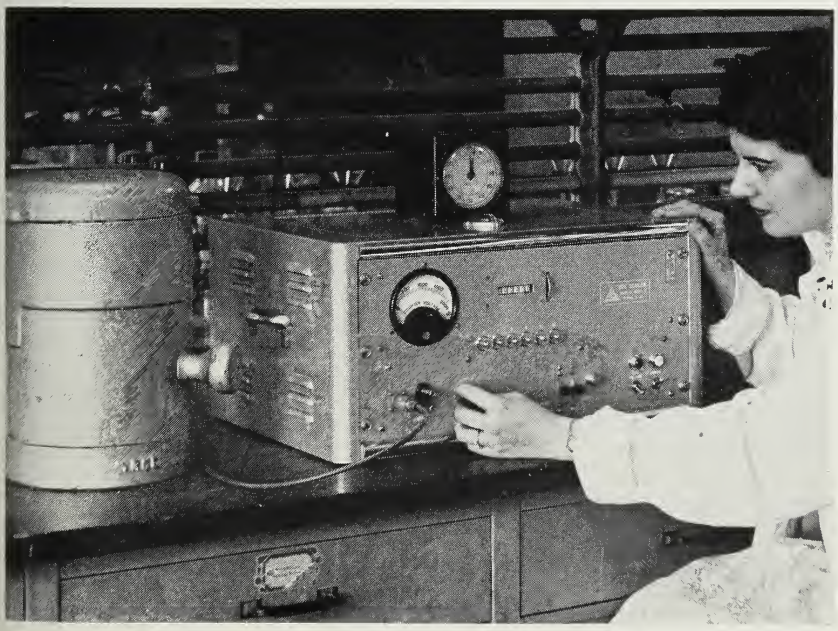
Three rooms are equipped with apparatus used in the preparation of rocks, diamond drill cores, and well cuttings for research studies.

Geochemistry Section

Six analytical laboratories: one devoted to analysis of coal purchased by the institutions of the State; one for analysis of coal, coke, and char in research on Illinois coals; one for analysis of rocks and brines; one for the study of oil sands and composition and properties of petroleum and natural gas; one for the determination of the heat value of coal; and one for determination of nitrogen in connection with coal analysis.

One microanalytical laboratory for rapid analysis of materials when very small samples are used.

Two research laboratories for the fundamental study of the chemical nature of coal.



Geiger counter apparatus for determining radioactivity of materials.

Three laboratories for the study of the physical and chemical properties of silicate materials at high temperature, surface properties of coal, coke, and char, and factors that affect efflorescent coating of building brick.

Two laboratories devoted to the study of organic fluorine compounds derived from fluorspar, deposits of which, in southern Illinois, are unique and rank first in production in the Western Hemisphere.

One X-ray laboratory for mineral identification and for study of atomic and molecular structure of minerals.

Three spectrographic laboratories for determining constituents present in trace amounts in minerals and rocks, including petroleum and petroleum products, coal, liquefied coal products, and new laboratory compounds.

One laboratory equipped with two armored cubicles in which experiments requiring special precaution from explosion are carried out.

One furnace room with electric and gas furnaces for ashing of coals, stabilization of precipitates in analytical work, investigation of chemical changes that take place in rocks and minerals when treated at various temperatures, and for the study of other temperature phenomena.

Two rooms for the preparation and drying of coal samples for analysis.

One small shop room equipped for use by the laboratory staff.

Experimental Laboratory Building

A special laboratory building, built in 1941, located near the University Power Plant, is used for the study on pilot-plant scale of the coke and char potentialities of Illinois coals and of the combustion characteristics of Illinois stoker coal. Equipment used in coking studies includes a pilot oven operated since 1944 which is designed to produce coke under semi-commercial heating conditions for evaluation of its physical and chemical properties, and a second oven, recently completed, for determining the extent of pressures exerted on coke oven walls during carbonization. This building also has a small machine shop for work in connection with maintenance of research equipment in the building.

Machine Shop

The Survey possesses a specially equipped machine shop in the Natural Resources Garage for the design and construction of research apparatus not available on the open market. The equipment includes one No. 2 milling machine, one modern lathe for moderately heavy

Special laboratory apparatus not available on the open market is designed and fabricated by a highly skilled technician in the Survey's shop.

work, one small lathe for light work, four drill presses of assorted sizes, and other accessory apparatus for the construction of instruments and specialized research apparatus.

Modern Research Apparatus

The equipment of the Survey's research laboratories includes, among other things, certain distinctive and specialized items, such as high-powered microscopes, X-ray, spectrographs, Geiger counters, high-pressure equipment, photoelectric potentiometers, infra-red spectro-

photometer, electronic photometer and photomultiplier, graphic recorders, refraction seismic equipment, earth resistivity equipment, special instruments for the study of radio wave transmission through geological formations, differential thermal analysis units, low-temperature fractional gas distillation equipment, apparatus for measuring gas absorption on solids, heat-of-wetting equipment, surface tension equipment, ultrasonic generators, viscosimeters, well depth measuring equipment, and many other unusual devices for obtaining important factual information on the mineral resources of the State.

ADMINISTRATIVE, SCIENTIFIC, AND TECHNICAL PERSONNEL

The key to creative research is the scientist. Careful attention has been given to the selection of research personnel to meet the high scientific standards of the Survey. Space does not permit the listing of all the scientific specialists of the State Geological Survey but there is given below the scientific and technical personnel who have directed the research and public service activities of the Survey.

Office of the Chief

M. M. Leighton, Chief; B.S., U. of Iowa, 1912, M.S., 1913; Ph.D., U. of Chicago, 1916; D.Sc., Southern Illinois University, 1954. Member of Iowa Geological Survey, summers of 1914 and 1915; faculty member of State U. of Wash., 1915-16; U. of Chicago, summer 1916; Iowa State Teachers College, 1916-17; State U. of Wash. (also Washington Geological Survey), 1917-18; Ohio State U., 1918-19; U. of Illinois (also State Geological Survey), 1919-23; Member of Ill. State Museum Board, 1937-; Vice Chairman Post-War Planning Commission, 1945-47; Member Advisory Committee to U. S. Geol. Survey, 1943-; Chief, Ill. State Geol. Survey, 1923-.

Enid Townley, Geologist and Assistant to the Chief; B.S., U. of Chicago, 1921, M.S., 1925. Midwest Refining Co., 1922; staff, Wellesley College, 1922-24; Guide Lecturer, Chicago Academy of Sciences, 1926-27; Geologist, Pure Oil Co., 1927-31; Geologist and Assistant to the Chief, Ill. State Geol. Survey, 1931-.

Gilbert O. Raasch, Geologist in Charge, Educational Extension; B.A., U. of Wisconsin, 1929, Ph.D., 1946. Curator, Wis. Geological Museum, 1929-36; Magnolia Petroleum Corp., 1936-37; Darby Petrol, 1937-38; Milwaukee Public Museum, 1940-42; Major, Air Force, 1942-46; Ill. State Geol. Survey, 1946-53.

Vivian Gordon, Head, Mineral Resource Records; Skelly Oil Co., 1937-42; Exec. Sec., Land and Production Dept., Globe Oil and Refining Co., 1942-46; Ill. State Geol. Survey, 1946-.

Anne E. Kovanda, Librarian; B.S., U. of Ill., 1937; B.L.S., 1942. Staff, U. of Ill. Journalism Library, 1941-42; Detroit Public Library, Technology Department, 1942-47; Ill. State Geol. Survey, 1947-.

Jane V. Olson, Associate Technical Editor; B.A., U. of New Mexico, 1939. Staff, Museum of New Mexico, 1939-40; Commerce Clearing House, 1941; Peabody Museum, Harvard U., 1942-43; Atlantic Monthly Co., 1943-46; Conde Nast Publications, Inc., 1946-49; Ill. State Geol. Survey, 1949-.

Geological Resources Section

Arthur Bevan, Principal Geologist in Charge of Geological Resources Section, and Acting Head of Coal Division; B.S., Ohio Wesleyan U., 1912, Sc.D., 1942; Ph.D., U. of Chicago, 1921. Faculty member, Ohio Wesleyan U., 1912-14 (acting Head, Dept. of Geol. 1913-14); Ohio State U., 1917-19; State U. of Montana, 1919-21 (also Montana Bureau of Mines, summers 1919-22); U. of Ill., 1921-29; U. of Chicago, summer 1924; Ill. State Geol. Survey, summers 1923-29; State Geologist of Virginia, 1929-47; Chairman, Division of Geology and Geography, National Research Council, 1946-49; Principal Geologist, Ill. State Geol. Survey, 1947-.

J. E. Lamar, Geologist and Head, Industrial Minerals Division; B.S., U. of Chicago, 1920; Ill. State Geol. Survey, 1920-.

A. H. Bell, Geologist and Head of Oil and Gas Division; B.A., U. of Toronto, 1917; Ph.D., U. of Chicago, 1926. Scholar, National Research Council of Canada, 1920-21; Geological Survey of Canada, 1914, 1920-23; Texas Co., 1924-26; Ill. State Geol. Survey, 1926-.

George E. Ekblaw, Geologist and Head, Engineering Geology and Topographic Mapping; A.B., U. of Ill., 1922, A.M., 1923; Ph.D., Stanford U., 1927. Ill. State Geol. Survey, 1920-25; 1927-.

H. B. Willman, Geologist and Head, Stratigraphy and Areal Geology; A.B., U. of Ill., 1926, M.A., 1928, Ph.D., 1931. Kentucky Geol. Survey, 1926; staff, U. of Ill., 1926-28; Ill. State Geol. Survey, 1927-.

Ralph E. Grim, Consulting Clay Mineralogist; Ph.B., Yale U., 1924; Ph.D., U. of Iowa, 1931. Staff, U. of Miss. and Miss. Geol. Survey, 1926-30; U. of Iowa, 1930-31; Ill. State Geol. Survey, 1931-50; U. of Ill., 1950-.

M. Wm. Pullen, Geologist and Head, Geophysical Research; B.A., Colgate U., 1938; M.S., Syracuse U., 1940; Ph.D., U. of Ill., 1950. Cunningham Oil Co., summers 1937, 1938. Staff, Syracuse U., 1938-40; U. of Ill., 1940-42; Ill. State Geol. Survey, 1942-53.

Frank C. Foley, Geologist and Head of Groundwater Geology and Geophysical Exploration; B.A., U. of Toronto, 1929; Ph.D., Princeton U., 1930-33; U. of North Dakota, 1933-41; State Geologist, North Dakota Geological Survey, 1938-41; U. S. Geol. Survey, 1941-42 and 1946-51; Major, Corps of Engineers, 1942-45; Ill. State Geol. Survey and U. of Ill., 1951-.

Paul A. Witherspoon, Petroleum Engineer and Head of Petroleum Engineering Division; B.S., U. of Pittsburgh, 1941; M.S., U. of Kansas, 1951. Phillips Petroleum Co., 1941-49; U. of Kansas, 1949-51; Ill. State Geol. Survey, 1951-.

Geochemistry Section

Frank H. Reed, Chief Chemist; A.B., Wabash College, 1911; Ph.D., U. of Chicago, 1917. Staff, Wabash College, 1913-14; Mich. State College, 1914-15; Sherwin-Williams Co., 1917-19; Butterworth-Judson Corp., 1912-22; Supt., Chemical Plant, Tower Manufacturing Co., 1922-27; Chemical Dye & Mfg. Co., 1927-28; Plant Supervisor, National Aniline & Chemical Co., 1928-30; Roessler & Hoslacher Chemical Co., 1930-31; Scientific Consultant, Federal Economic Administration, Northwest Europe, 1945; Visiting expert to General MacArthur's Headquarters, Tokyo, December 1948-February 1949; Ill. State Geol. Survey, 1931-.

O. W. Rees, Chemist and Head, Analytical Chemistry; B.S., Earlham College, 1922; M.S., U. of Ill., 1925, Ph.D., 1931. Staff, Earlham College, 1922-24; Ill. State Water Survey, 1925-30; Ill. State Geol. Survey, 1931-.

G. C. Finger, Chemist and Head, Fluorine Chemistry; B.S., U. of Ill., 1927, M.S., 1928, Ph.D., 1938. Staff, Purdue U., 1928-30; U. of Ill., 1930-32; Ill. State Geol. Survey, 1933-.

W. F. Bradley, Chemist and Head, X-Ray Division; A.B., U. of Ill., 1930, Ph.D., 1935. Ill. State Geol. Survey, 1934-.

J. S. Machin, Chemist and Head, Physical Chemistry; A.B., Westminster College (Mo.), 1921; M.S., U. of Ill., 1922; Ph.D., U. of Chicago, 1932. Staff, Westminster College, 1922-24; Sioux Falls College, 1924-36; Ill. State Geol. Survey, 1936-.

G. R. Yohe, Chemist and Head, Coal Chemistry; B.A., Cornell College, 1925; M.S., U. of Ill., 1927, Ph.D., 1929. Goodyear Tire and Rubber Co., 1929-30; staff, Ohio Wesleyan U., 1930-37; Ill. State Geol. Survey, 1937-.

H. W. Jackman, Chemical Engineer and Head, Chemical Engineering; B.S.E., U. of Mich., 1923, M.S.E., 1924. Champion Spark Plug

Co., 1924-25; Chief Chemist and Supt. of Manufacture, Battle Creek Gas Co., 1925-41; Ill. State Geol. Survey, 1942-.

Mineral Economics

W. H. Voskuil, Mineral Economist; B.S., U. of Wis., 1921, M.S., 1922, Ph.D., 1924. Staff, U. of Wis., 1922-24; Wharton School of Finance, U. of Penna., 1924-30; Chief Mineral Economist, National Industrial Conference Board, 1930-31; Mineral Economist, U. S. Bureau of Mines, 1931; Consultant, Office of Price Administration, 1941-42; Council of Foreign Relations, 1943; Ill. State Geol. Survey, 1931- and U. of Ill., 1949-.

In the Geological Resources Section, the full-time staff of the Coal Division numbers 10; Oil and Gas, 7; Petroleum Engineering, 1; Industrial Minerals, 5; Clay Resources and Clay Mineral Technology, 3; Groundwater Geology and Geophysical Exploration, 8; Geophysical Research, 3; Engineering Geology, 2; and Stratigraphy and Areal Geology, 10.

In the Geochemistry Section, the full-time staff of the Division of Coal Chemistry numbers 3; Physical Chemistry, 4; Flourine Chemistry, 2; Chemical Engineering, 7; X-ray, 1; and Analytical Chemistry, 12.

The staff of Mineral Economics includes three persons and the staff of Educational Extension, two.

The Survey has nine research affiliates and six consultants, most of whom are faculty members of the University of Chicago, University of Illinois, Northwestern University, and University of Southern Illinois.

The Library staff includes 2, Mineral Resource Records Division, 8, and Editing and Publications, 4. An additional 26 persons handle photography, stenographic service, correspondence files, office information, financial records, mailing service, machine shop work, and maintenance of motor vehicles.

Twenty college students, most of them specializing in geology, are employed part-time as research and technical assistants.

Publications

Prompt publication of results obtained from research work is essential to its greatest effectiveness. Every effort is made by the Survey to bring its information to the citizens of the State as soon as possible consistent with accuracy.

Publications issued during the year include the following:

Bulletin:

78. Minable Coal Reserves of Illinois: G. H. Cady et al. 1953. 138 pp., 8 pls., 37 figs., 1 table.

Geology and characteristics of coal seams and tabulated listing of reserves; color plates show areas of classified reserves.

Reports of Investigations:

162. Geologic Aspects of Radio Wave Transmission: M. William Pullen. 1953. 73 pp., 41 figs.
Describes the influence of earth material on radio field intensity.

165. Pleistocene Deposits Below the Wisconsin Drift in Northeastern Illinois: Leland Horberg. 1953. 61 pp., 2 pls., 16 figs., 1 table.
A comprehensive discussion of the glacial deposits older than Wisconsin and their relations to possible underground water supplies.

166. Siliceous Materials of Extreme Southern Illinois: J. E. Lamar. 1953. 39 pp., 17 figs., 11 tables.
Brings together data from the literature and new information concerning these mineral resources.

168. Illinois Mineral Industry in 1951 and 1952: W. H. Voskuil. 1953. 52 pp., 17 figs., 39 tables.
Statistical summary and economic review.

169. Microanalysis of Organic Compounds Containing Fluorine: H. S. Clark and O. W. Rees. 1954. 19 pp., 4 figs., 1 table.
Methods for the analysis of organic compounds containing fluorine, particularly the analysis of compounds containing halogens in addition to fluorine.

170. Petrology and Sedimentation of Upper Chester Sandstones: Raymond Siever. 1954. (Reprinted from Jour. Sedimentary Petrology, vol. 23, no. 4, pp. 207-219, 1954.) 13 pp., 1 pl., 6 figs., 1 table.
The relationship between the mineral constituents and textures of upper Chester sandstones and the environments of deposition, tectonic activity, and possible source areas.

171. Investigation of Rank in Coal by Differential Thermal Analysis: H. D. Glass. 1954. (Reprinted from Econ. Geol., vol. 49, no. 3, pp. 294-309, 1954.) 17 pp., 10 figs., 1 table.
A new method for identifying rank in coal.

172. Structural History of the Centralia Area: Robert L. Brownfield. 1954. 31 pp., 11 figs., 1 table.
Includes two structure and five isopach maps, and discusses historically the major and minor structural features of the area.

173. High Temperature Phases from Kaolinite and Halloysite: Herbert D. Glass. 1954. (Reprinted from Am. Mineralogy, vol. 39, nos. 3-4, pp. 193-207, 1954.) 15 pp., 2 figs., 1 table.
An investigation of the phase changes upon heating in kaolinite and halloysite clays, and an explanation of the cause of variation in firing sequences.

174. Extension of Tazewell Glacial Substage of Western Illinois and Eastern Iowa (a cooperative study with the Iowa Geological Survey): Paul R. Shaffer. 1954. (Reprinted from Geol. Soc. Am. Bull., vol. 65, pp. 443-456, 1954.) 13 pp., 8 figs.
Data showing that the Shelbyville glacier crossed the Mississippi River into Iowa a short distance, between Fulton and Cordova, and that several glacial lakes existed in the Mississippi and Green River valleys.

Illinois Petroleum Series:

68. Developments in Illinois and Indiana in 1952: A. H. Bell and D. C. Sutton. 1953. (Reprinted from Bull. Am. Assoc. Petr. Geol., vol. 37, no. 6, pp. 1301-1314, 1953.) 14 pp., 1 fig., 10 tables.

69. Oil and Gas Development in Illinois During 1952: A. H. Bell and Virginia Kline. 1953. (Reprinted from Statistics of Oil and Gas De-

velopment and Production Covering 1952. Am. Inst. Min. Met. Eng.) 53 pp. 3 figs., 7 tables.

Circulars:

185. Summary of Water Flood Operations in Illinois Oil Pools During 1952: Paul A. Witherspoon et al. 1953. (Reprinted from Rept. Interstate Oil Compact Commission, 1953.) 23 pp., 5 figs., 2 tables.

Summarizes the important work of the Commission in secondary recovery of oil in Illinois in 1952.

186. Mineral Resource Research and Activities of the State Geological Survey, 1952-1953: M. M. Leighton, 1954. (Reprinted from the Annual Report of the Department of Registration and Education, for fiscal year 1952-1953.) 54 pp., illustrated.

Describes the various activities of the State Geological Survey for fiscal year July 1, 1952, to June 30, 1953.

188. Short Papers on Geologic Subjects: H. R. Schwalb, J. S. Dobrovolny, and W. D. Johns. 1954. (Reprinted from Trans. Ill. Acad. Sci., vol. 46, 1953.) 20 pp., illus.

Three papers on aspects of Illinois geology which were presented at the 1953 meeting of the Illinois Academy of Science.

189. Twenty-five Years of Engineering Geology in Illinois: G. E. Ekblaw. 1954. (Reprinted from Trans. Ill. Acad. Sci., vol. 46, 1953.) 10 pp.

Describes principally some of the engineering problems about which Survey geologists have been consulted.

190. Plastic and Swelling Properties of Illinois Coals: O. W. Rees and E. D. Pierron. 1954. 11 pp., 3 figs., 3 tables.

Data on Illinois coal arranged according to seam, rank, county. Similar data for representative U. S. coals of the bituminous rank are included for comparison.

Miscellaneous:

Oil and Gas Drilling Report, mimeographed, issued monthly.
Supplementary Book of Charts for Oil and Gas Drilling Report, 1953.

The Board of Natural Resources and Conservation

BOARD OF NATURAL RESOURCES AND CONSERVATION

Honorable Vera M. Binks, Chairman

Ex-Officio Members:

W. L. Everitt, representing the President, University of Illinois

Delyte W. Morris, President, Southern Illinois University

Scientific Specialists:

Biology—A. E. Emerson, University of Chicago

Chemistry—Roger Adams, University of Illinois

Engineering—Robert H. Anderson, C. K. Willett, Consulting Engineers, Dixon

Forestry—Lewis H. Tiffany, Northwestern University, Vice President and Secretary to the Board

Geology—W. H. Newhouse, University of Chicago

The Board of Natural Resources and Conservation, which directs and controls the work of the Geological Survey, the Natural History Survey, and the Water Survey, was created by the Civil Administrative Code in 1917. It is composed of distinguished scientists, each qualified by at least ten years of professional experience in his special field, as shown above, and functions under the ex-officio chairmanship of the Director of the State Department of Registration and Education.

Under the law this Board selects and appoints, without reference to the State Civil Service law, all members of the technical staffs and approves the budgets and programs of the three scientific surveys. The Board is traditionally nonpartisan and its members serve without pay. Membership is by appointment of the Governor, and it is a standing tribute to the broad vision of our State administration and to the abilities of the Board members that since the Board's inception, changes on the Board have usually been made only upon the death or retirement of a member. Because several sciences, four different universities, and industry are represented by the Board membership, its points of view insure broad representation of the interests of the State.

The Board, which meets at regular intervals, receives and carefully studies quarterly reports from the three chiefs of the scientific surveys. It determines policies and acts in an advisory capacity over the manifold research and activities of the three surveys which are concerned with aiding in the development of and augmenting the natural resources of the State. The devotion of Board members to the responsibilities imposed upon them by law, their recognition of measures consistent with sound public policy, their comprehension of fruitful research programs, and their exercise of great care in selection of scientific staffs have resulted in national and international recognition of Illinois and its wealth of natural resources.

Recent outstanding capital improvements to the physical facilities of all three surveys received the unqualified approval of the Board be-

fore they were submitted for the consideration of State authorities and the Legislature. Although the scientific surveys are administered by the State Department of Registration and Education, location of the surveys' headquarters and principal laboratories on the University of Illinois campus at Urbana offers many advantages. Research is furthered through the availability of the University's libraries and some of the laboratories and experimental field-plots, and in like manner survey facilities are made available to University staff members and some advanced students seeking professional training. Cordial relations and a generous exchange of information between University and survey staffs make for prompt and effective dissemination of the results of research. Operational economy is also achieved by one system, maintained by the University, that provides water, heat, light, and other services for the surveys and the University.

(14740)